AGRICULTURAL ENGINEERING

AUGUST • 1949

Population, Soil and Engineering—Conservation's Challenge *Robert S. Calkins*

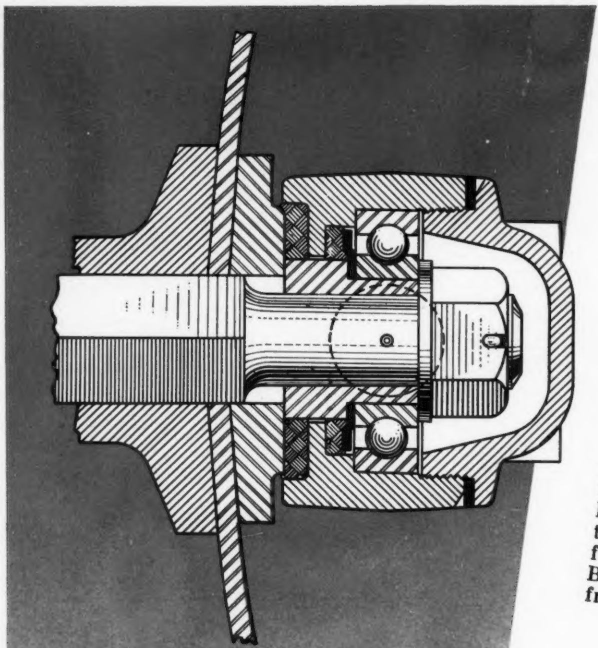
Hydraulic Circuits for Farm Tractor Applications *Joseph F. Ziskal*

Recent Results of Sugar Beet Storage Experiments *Clarence M. Hansen*

Effect of Slope and Length of Run on Erosion Under Irrigation *Stephen J. Mech*

Results of Drainage Investigations in Plastic Till Soils *E. H. Kidder, W. F. Lytle*

THE JOURNAL OF THE AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS



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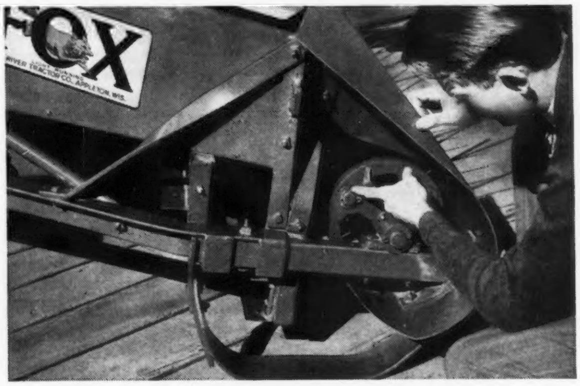
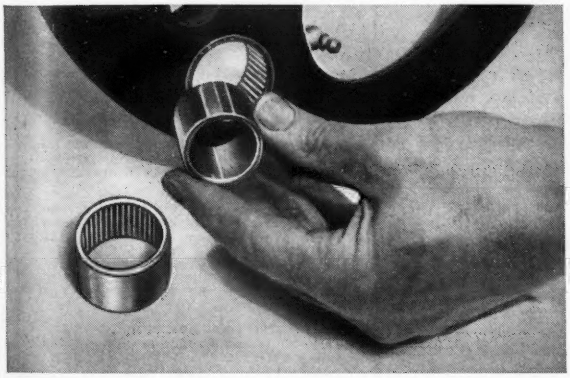


Six Needle Bearings in the pick-up unit, for example, keep wear to a minimum and assure efficient use of lubricants. Needle Bearings are also used in the cutter-bar attachment, for harvesting standing crops, and 7 Needle Bearings are used in the Crop Blower.



Lubricant is effectively retained by the turned-in lips of the Needle Bearing which ride close to the shaft, or in this case to the hardened and ground inner race. These close-fitting lips also help to keep out dust, moisture and chaff during pick-up operation.

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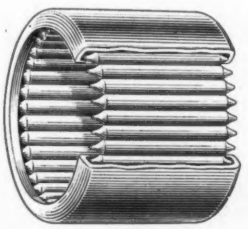

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AGRICULTURAL ENGINEERING

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CONTENTS FOR AUGUST, 1949

Vol. 30, No. 8

EDITORIAL 365

POPULATION, SOIL AND ENGINEERING 367
By Robert S. Calkins

THE GRAIN STORAGE PROBLEM IN 1949 370
By William McArthur

HYDRAULIC CIRCUITS FOR FARM TRACTORS 371
By Joseph F. Ziskal

THE STORAGE OF SUGAR BEETS 377
By C. M. Hansen

EFFECT OF SLOPE AND LENGTH OF RUN ON EROSION UNDER IRRIGATION 379
By Stephen J. Mech

DRAINAGE INVESTIGATIONS IN THE PLASTIC TILL SOILS OF NORTHEASTERN ILLINOIS 384
By E. H. Kidder and W. F. Lytle

WATER AND IRRIGATION NEEDS OF THE PACIFIC COAST 387
By Irvin H. Althouse

NEWS SECTION 390

PERSONNEL SERVICE BULLETIN 402

AGRICULTURAL ENGINEERING is indexed regularly by Engineering Index, Inc.

INDEX TO ADVERTISERS

Aeroquip Corp. 403
Atlas Powder Co. 401
Blood Brothers Machine Co. .... 3rd Cover
J. I. Case Co. .... 2nd Cover
Chain Belt Co. 364
Douglas Fir Plywood Assn. 366
Electric Wheel Co. 400
Ethyl Corp. 393
French & Hecht, Inc. 402
International Nickel Co. 361
Johns-Manville Corp. 360
Link-Belt Co. 391
Massey-Harris Co. 399
Mechanics Universal Joint Div., Borg Warner Corp. 359
Minneapolis-Moline Co. 397
The Oliver Corp. 395
Portland Cement Assn. 398
Reynolds Metals Co. 362
The Sisalkraft Co. 394
Skinner Irrigation Co. 402
Stow Mfg. Co. 396
The Texas Co. 363
Timken Roller Bearing Co. .... 4th Cover
The Torrington Co. 357
Tuthill Pump Co. 404
Wisconsin Motor Corp. 400

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EDITORIAL

The Day of Reckoning Is Here

IN contemplating the possible significance of some figures on soil erosion and population we came up with the following:

About 361 million acres of our best crop land are in use this year. Some 158 million acres might be put into production or more intensive production at a price which might not be prohibitive. At 3 acres per person this would provide food for about 53 million more people.

With an annual increase in population of about 2 million, the approximate average rate for the past 9 years, this additional population would be with us in only 26 or 27 years — less than a generation.

At this rate, many of us might live to know famine or heavy dependence on imported foods. Our children would really feel the pinch of scarcer food, lower quality food, and higher food costs.

Gradually increasing economic pressures might considerably delay the ultimate day of reckoning, by reducing the rate of population growth, reducing waste, improving farm production efficiency, and causing more intensive cultivation.

But economic pressures mean poorer living and poorer business. If we can claim to be an even slightly forward-looking people, the day of reckoning with the food problem is not a generation away; it is here, now!

It is a day for reckoning with the 500,000 acres, 3 billion tons, $3 billion dollars worth of capacity to support 170,000 people, which is still eroding annually from our farm foundation of prosperity and national strength. The prospect that in another generation soil erosion may be cutting back the quantity and quality of our national life to that extent is not rosy.

Industries directly dependent on farm trade may readily justify, on a dividend basis, increased direct support of soil and water conservation. And the further removed any group is from direct association with the production of the necessities of life, the more it needs to be sure that someone else is seeing to the continuing efficient production of these necessities.

The argument that many other factors have contributed to the downfall of historic civilizations is familiar, and to a large extent true. But whether their wasted soils were cause or effect, they are still relatively barren, and new civilizations have grown up on greener pastures.

It is a day for reckoning with other possibilities in the conservation of limited natural resources, while we take a fresh look at the meaning and values of life, individually and collectively, and at the possibilities of extending by intelligent action a civilization made possible largely by extreme good fortune.

It is a day for considering the simple mathematics of human maintenance and progress. More time required to earn groceries leaves less time and money for other things. Means available for the development and practice of civilization are the remainder which may or may not exist after subtracting our animal subsistence requirements from the total time, energy, and other resources at our disposal.

It is a day for supporting further work in agricultural science and engineering in anticipation of their further usefulness in conserving human life and human values.

For many of the basic figures used and some of the ideas expressed, we are indebted to "Industry's Stake in Conservation,"* by Fred A. Wirt, a distinguished past-president of American Society of Agricultural Engineers, and missionary of sound economy and free enterprise.

If our information or deductions are seriously in error, and the facts give us a few more years of grace, we would like to know about it. If not, then a lot more people should be made to realize that the day of reckoning on conservation is here.

*An address before the Conservation Forum, April 15, 1949, held in conjunction with the National Country Life Exposition, Philadelphia, Pa., and now published in pamphlet form by the Soil Conservation Society of America (Upper Darby, Pa.)

Flexibility in Engineering Employment

A RECENT U. S. Department of Labor report on the "Employment Outlook for Engineers" indicates that "many of the graduates of the next four years may be unable to find engineering jobs, although their training may help them get administrative, sales, or other positions in industry."

This picture is based on prospective graduations of 47,000 in 1950, 36,000 in 1951, and 29,000 in 1952, against a replacement requirement estimated at 9,000 to 10,000 per year and 8,000 prospective annual increase in total employment of engineers. The report further notes a considerable flexibility in employment of engineers, as to geographic location, industrial field, and branch of technical specialization.

Graduates in agricultural engineering during the next several years may therefore have to expect to compete with possibly several thousand graduates in other branches of engineering, who will be casting about for beginning jobs in any field, and not ignoring agricultural engineering. By the same token, much of the whole broad field of engineering is theoretically open to applications from agricultural engineers with sound basic training in engineering. But the competition will probably be tougher than in recent years.

In any individual case it would seem that an agricultural engineering graduate might find his greatest usefulness and opportunity in agricultural engineering. And it is to be hoped that potential increases in agricultural engineering employment may materialize fast enough to absorb all of the well-qualified graduates in this field.

From another viewpoint, it is apparent that agricultural engineering has benefited substantially by the infiltration of engineers trained and experienced in other branches of the profession, and could continue to benefit by such infiltration, within reasonable limits.

It would also be a help to agricultural engineers to have in other branches of engineering an increased number of friends who are really well informed concerning the engineering problems of agriculture and the opportunities for service and the enlargement of engineering which they offer. One way in which this can come about is by those agricultural engineers who may have the inclination and opportunity to do so transferring into adjacent engineering fields.

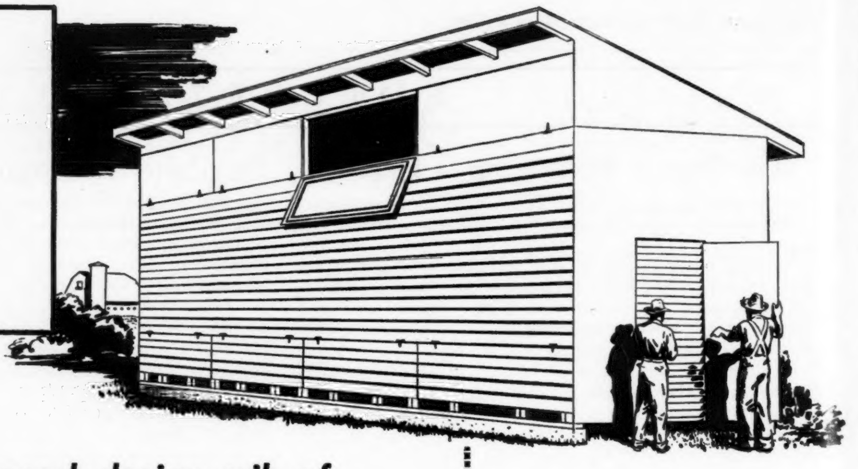
It appears from this study that engineering viewpoint and technique have been more useful and significant than specialization within engineering, both to engineers and to the world they serve.

Notation in the report that "the types of industrial activity which use engineers expanded rapidly (during the profession's long-term growth); and engineers were used to an increasing extent within these industries," also seems significant. It suggests a future of enlarging opportunity for agricultural engineers. It also suggests that there may be other types of activity which have not yet used engineers to any great extent, and which might profit greatly by their use.

Since engineers gravitate at apparently satisfactory rates toward areas, industries, and branches of engineering technology where they are in greatest demand, the problem of utilizing additional engineers is not one of distribution within the established field. It is a problem of recognizing and developing additional opportunities for application of engineering viewpoint and technique. It will mean recognizing the physical problems in activities not yet employing engineers.

It will mean taking or making opportunities to apply and prove engineering on farms and in numerous other small units of private enterprise, as well as in some of the departments of large business which are not yet making extensive use of engineers. It will mean looking for "Engineers Wanted" signs, not only in employment offices and classified ads, but in the ways in which men live and work, the methods and equipment they use, the ways they think, and the effectiveness of their efforts. This is a problem for the whole organized engineering profession as well as for recent graduates and other unattached individuals.

Planned for Natural or Forced-Air Curing



—this advanced-design crib of

Exterior Plywood

will help farmers qualify for CCC storage loans

BRINGING CORN to a safe moisture content, quickly and safely, is a major problem — particularly in warm, humid areas. The advent of hybrid varieties and mechanical pickers, too, presents a demand for more efficient drying facilities.

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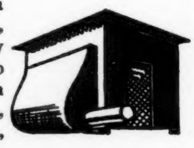
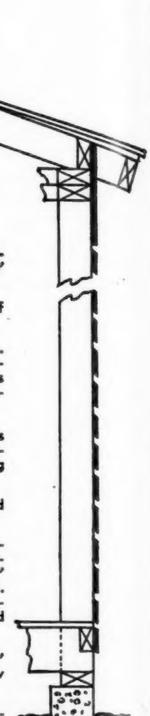
(1) Use of the big, rigid plywood panels makes building easier, with a reduction of labor time and costs. The plywood roof, floor and drop-sides of the structure are easier to fabricate, and present a tight, protective structure at these points.

(2) It is ideal for mechanical forced-air drying. Air can be blown through the cribbing without loss because the plywood ends, roof and floor provide a tight "tunnel" for air passage.

(3) For drying with forced air, wood side pieces may be attached as in Figure 2 (below). Canvas is used to cover the plywood, forming an air duct by which the air can be forced laterally through the crib.

Suggest this design to farmers who are seeking efficient corn storage facilities which will qualify under the CCC program. Plans for this crib are available free. Write the Douglas Fir Plywood Association office nearest you: Tacoma Bldg., Tacoma 2, Wash.; 848 Daily News Bldg., Chicago 6; 1232 Shoreham Bldg., Washington 5, D. C.; 500 Fifth Ave., New York City 18.





CONSTRUCTION PROCEDURE

SIZE: 8′ wide (variable for different climates) x 12′ high x 16′ long (also variable).

CAPACITY: 75 bu. per foot of length in 8′ width.

Floor joists: 2″ x 10″, 16″ o. c. placed on 8′ concrete foundation. 4″ x 4″ x 16′ sills. Ends of joists left open to minimize rat hiding places.

Studs: 2″ x 6″, spiked to ends of joists. Cut in 2″ x 4″ nailing pieces for flooring along both sides and down center.

Flooring: 3/8″ Exterior plywood panels, laid across joists.

Nail 1″ x 6″ diagonal windbracing from either end on inside of studs. Bolt 2″ x 6″ cross-ties 4′ o. c. below plate. Nail 1″ x 6″ crib siding horizontally outside studs, spaced 1″ apart.

Filling doors formed from 3/8″ plywood nailed to sides below shed roof.

End walls: 3/8″ Exterior plywood. Back up joints with 2″ x 4″ blocking between studs. Door in one end is 32″ x 7′.

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For all uses on the farm, specify EXTERIOR-TYPE Douglas fir plywood—bonded with completely waterproof phenolic resin, especially for permanent exposure to weather, water or abnormal moisture conditions. The "EXT-DFPA" grade-trademark on every panel affords positive identification.

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AGRICULTURAL ENGINEERING

VOL. 30 AUGUST, 1949 No. 8

Population, Soil and Engineering

By Robert S. Calkins
MEMBER A.S.A.E.

THERE is urgent need in America for a better and clearer understanding of the problems that confront all of us in conserving our resources. These problems concern population, soils, engineering, and many other phases.

All of us have been brought up to believe that the resources of America are unlimited. We found during the war that there *were* limitations, and serious ones. Succeeding generations should be brought up to know that we must live within the limitations that exist. Our school curriculums could well be changed to incorporate information on the need for conservation of soil and water, as well as other resources, into programs of classroom instruction. The National Association of Soil Conservation Districts believes that we need not develop courses in conservation as such, but we believe that the philosophy of conservation should be integrated into the regular courses—into the three R's, if you please—as well as other established subjects. In addition, there is a tremendous job of adult education to be done.

Yes, in addition to teacher and the pupil, the businessman and laborer, clergyman and congregation, parent and child, and congressman and voter must be made aware of the fact that each and every one of us has a stake in this problem. They must be made to realize that their welfare is threatened.

It takes money to do the job. The money to accomplish the objective must come from public appropriations and from private interests. It is a sound investment for both. Public appropriations used for soil and water conservation are returned to taxpayers in the form of increased income taxes from more profitable farm production, in the form of improved valuation of the tax base, and in the form of improvement in the ability of the land to continue production. Private investments are returned in the form of increased yields from farm land and a better balance in the operation of individual farms and ranches.

Let's examine the specific phases of this vast problem of population, soils and engineering.

Population in the United States has grown from 76,000,000 in 1900 to an estimated 146,000,000 in 1949. Each year we experience an increase of about 2,000,000 people in this nation. This latter figure is obtained by the simple subtraction of the number who die from the number born. These figures are all in round numbers. Actuarial statistics are available to all who desire them. The figures are used here to indicate the trend of population in America. It is rising every year.

In the early 1900's the life expectancy of a person born during that period was about 55 years. Fifteen to twenty years ago, the life expectancy figure had increased to about 62 years. They tell me that a baby born today has a life expectancy of 67 years.

What about soils? There is plenty of concrete evidence to show that man has destroyed his heritage of the land. The Bible tells us that the desert area of Lebanon once grew a mighty forest. A forest to which King Solomon sent 80,000 men to fell trees. We have heard of the decline of civilization in the Mayan Peninsula because the soil had eroded to the point where the population could not be supported on produce from the land. We have heard of the tragic situation in China where rural populations often run as high as 1,500 people per square mile and where a ten-acre plot is considered a big farm — to say nothing of the dense populations in the great cities such as Hong Kong and Shanghai. There are many other examples. You undoubtedly know of them.

Let me give you some information which was sent to us last winter by Senor Zacarias Rivera, president of the Insular Association of Soil Conservation District Supervisors of Puerto Rico. Senor Rivera writes:

> "The diminishing productivity of Puerto Rican soil, grim as it is, is not the only important factor and cause of our very grave land problem. Just as important is the pressure of a big and ever-increasing population on too little land. We have here approximately 0.36 acres of arable land per inhabitant. According to official reports each inhabitant requires three acres to live with a decent standard; therefore, we have a deficit of 2.64 acres per person. If this is multiplied by two million, which is our total population, the result is a total approximate deficit of 5,280,000 acres, or more than seven times the amount of arable land that we actually have. To make the situation more difficult to handle, our population increases at the rate of 60,000 per year and as each new inhabitant requires his share of three acres to live, our land deficit is increased each year by 180,000 acres.
>
> "The technical agriculturists and farmers of any nation must assume their share of the responsibility for the proper feeding of the population. If the population is well fed, the farmers as a group have succeeded. If it is poorly fed, the farmers have failed in their life work. But here in Puerto Rico we 56,000 farmers are beaten before we start, for lack of land. Emigration would be a great help in the solution of our land problem, but so far it has not been done in sufficient numbers to make it significant. *It would suit that purpose very well if any of the states should have an unused tract of land and generously offer it to us to resettle.*"

This picture of a John Deere tractor with "quik-tatch" cultivator, cultivating corn planted on the contour, is a typical example of how farmers, with the help of agricultural engineers and other agricultural scientists, are making definite progress in the direction of proper use of land and management of water

This is an address delivered at the annual meeting of the American Society of Agricultural Engineers at East Lansing, Mich., June, 1949.

ROBERT S. CALKINS is executive secretary, National Association of Soil Conservation Districts, Millbrook, N.Y.

You have gathered here today from almost every state in the Union. Let me ask you: Where in the United States could we place 60,000 people from Puerto Rico each year? The problem strikes uncomfortably close to home. We must not forget that Puerto Rico is a part of the United States. If Puerto Rico is not close enough, let me suggest you read an article "Ghost Town" in the spring (1949) issue of "The Land," in which Waters S. Davis, president of the Association of Texas Soil Conservation District Supervisors, tells that the town of Rhonesboro, Tex., has changed from a thriving community in 1910 to a ghost town today because soil erosion has taken its toll.

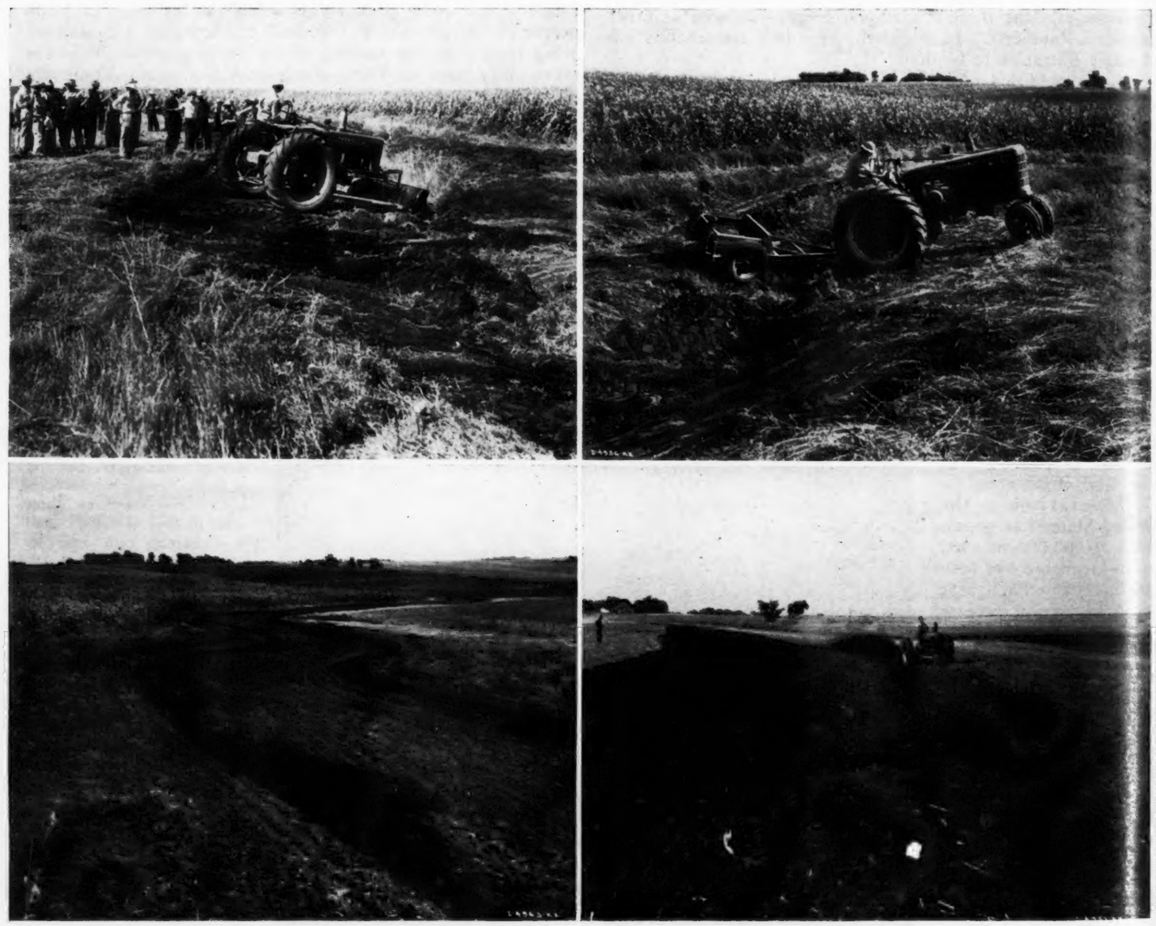
We in America cannot be proud of our record. Our history books tell us of the migration of people from the East to the Mid West and on to the West. They say the farms were "wornout." We know now that they were washed out, eroded to the point where it did not pay to farm them longer. Dr. H. H. Bennett, chief of the Soil Conservation Service, has said that we are losing the equivalent of 500,000 acres of land each year through erosion of wind and water. Time is running out! Conservation can't wait!

Despite what some people in America are saying, time is running out. It is difficult to be patient with those who have complacent attitudes and say: "Why get excited?" "Scare stories!" "Scientific developments will take care of us!" "Move to the tropics!" Such statements are deplorable but deserve a forceful answer.

"Why get excited?" The conservation of our soil and water resources is the most exciting and the greatest problem in America. We all like to eat and we all need healthful food. Unless we conserve our renewable natural resources, we may not get what we need and want, and we may once again face ration boards to get our pound of sugar and our pair of shoes. Annual surpluses that we may experience now are bound to dwindle as our population increases and acres of arable land decrease through wind and water erosion.

"Scare Stories!" Read your history books; read the Bible. The record is dismal. Let us heed the words of Dr. Hugh Bennett in his pamphlet, "Our American Land," in which he says: "Land, therefore, is our base; for everything we do, all we share, even whatever we amount to as a great people, begins and rests on the sustained productivity of our agricultural lands."

"Scientific developments will take care of us!" It is quite true that tremendous advancements have been made in the agricultural sciences. Fortunately for us this has been and is true. With our vast scientific knowledge, the improvement of our techniques, improvements in farm machinery and the use of fertilizers, our per acre yields are not a great deal higher today than they were when our forefathers began farming operations on this continent. Surely we need all the scientific improvement we are capable of developing.



These four pictures exemplify the philosophy of the NASCD motto "With the right to own goes the duty of conserve." The two top views show Farmall tractors moving earth with 6-ft Servis bulldozer and 1-yd Duplex scoop to fill a long, twisting gully and forming a grass-seeded waterway in its place, as shown in the lower left view. In the lower right view is shown a Farmall tractor and Servis whirlwind terracer building a level-type terrace

Those who have the complacent attitude say that one great hope is the possible development of food production from atomic energy processes. They may be right. We do not know yet whether they are or not. Recently an article by Bruce Bliven, in "This Week" magazine which comes as a supplement to many Sunday newspapers in America, predicted that atomic energy applied to ponds or reservoirs under certain conditions would produce a palatable, nourishing soup. Perhaps so, and we may one day be happy about this development, but let me ask you, shall we pin our future on this, or shall we plan now to continue a large-scale conservation program to utilize to the fullest extent our soil and water resources? If it comes to a choice between the soup from ponds or steak and French fries, let's continue to produce beef and potatoes!

"Move to the tropics!" This may sound feasible, but is it? You engineers in industry manufacturing and distributing farm machinery, hay-drying equipment, building materials, or electrical apparatus can appreciate the terrific costs of moving great industries and the people who man the plants over long distances. Would our markets absorb these costs? To me the logical thing to do is to use our soil and water resources so that they will continuously produce food and fiber for the people of America.

LOGICAL USE OF SOIL AND WATER RESOURCES

There are three things we must do to accomplish this. First, we must change our ideas concerning ownership of land. It has been our conception that ownership of land in fee simple, absolute, gave the owner the right to do with that land as he wished. We must change that concept so that those who own and those who operate land consider themselves as stewards or trustees of the land, the duty of the trustee being to see to it that the life tenant receives a fair income and that the succeeding owners receive the land, the capital of the trust, in an improved condition. The motto of the National Association of Soil Conservation Districts is "With the right to own goes the duty to conserve." Gradually this philosophy is being put into practice.

The second thing we must do is to continue to develop the science of proper land use. This science combines and coordinates the natural and applied sciences of agronomy, biology, engineering, forestry, hydrology, soils technology, and many others towards the proper use of land and management of water. Here is a great challenge and an unlimited opportunity for agricultural engineers to make their contribution to agriculture and industry. Of the conservation practices being applied to the land through Soil Conservation Districts, 35 to 45 per cent of the work load is in engineering practices. In addition to this, there are many problems to be solved in the development of machinery to prepare the land, plant the fields and harvest the crops. There are many problems in the transportation, storage, and use of the produce from the fields that require sound thinking and practical solutions. The field is wide open for the fullest use of your talents.

Fortunately, America leads in the development of the science of proper land use and all that the term implies. During the past 25 years, much excellent progress has been made by the experiment stations, the land-grant colleges, the U. S. Department of Agriculture, American industry, and owners and operators of our farms and ranches. It is significant to note that many foreign nations have sent their people to America to study the remarkable progress that has been made in this coordinated science. But we must not rest on these laurels. We must constantly advance our knowledge in the development of the science of proper land use.

The third and most important thing that we must do is apply this coordinated science to every acre in America. This is a tremendous job, and we must exercise great care in the method of doing it. One way is to do it by mandatory legislation. This would mean that we must change our form of government and give police power to an individual or a minority group to dictate to our farmers and ranchers how, what, and when they may plow, plant, and harvest. We rejected that kind of thinking nearly 200 years ago and we have continually rejected it since.

Another way to do it would be to bribe farmers and ranchers to do the job. We could put each one on the federal or state payroll and reward each one annually for using his land correctly. Let me remind you that the person or persons who signed the checks would have a great deal of power over American agriculture, and I don't think that we want to tolerate that! We must guard against these two methods as there are people in America who, due to the urgency of the problem, recommend these undesirable methods.

The way that we can accomplish this great task is through soil conservation districts. This is the method that has evolved in the past twelve years through democratic processes. It is the method that is being used on over three-fourths of the agricultural lands of the United States today. There is nothing complicated about soil conservation districts. They are simply groups of farmers or ranchers legally organized under state laws — and every state has such a law — to coordinate the efforts of local, state, and federal agencies in cooperation with private interests to plan conservation for and apply it to the land.

To do all that must be done, I am sure you will agree that it is imperative that we develop a better understanding of the problem in the minds of the citizens of our country. Here is where everyone can help. You leaders in the field of agricultural engineering can help. Let me encourage you to do so. The problem is political; it is economic; it is social; and it is scientific.

There are today over 11,000 supervisors, directors, or commissioners in more than 2,100 soil conservation districts devoting their time and energies to making the conservation of our renewable natural resources a reality. These men and women (there are a few of the latter) serve without pay because of their intense interest in the future of America. Soil conservation districts represent one of the great achievements of America. It is democracy at the grass roots! It is the American way!

With the continued backing of every American, soil conservation districts can and will continue their work to make the future of our nation secure.

Pioneering in India the American Way

TO THE EDITOR:

I HAVE established a farm in the jungles of North India to train and settle Anglo-Indian boys and girls on the land. We have a central farm of 100 acres (more to be added later) and as each boy acquires sufficient knowledge and skill he will be set up on a 15-acre plot of land as a beginning. This boy will have access to the heavier machinery and equipment on the central farm, but he must in return assist in training other young people who may come. We take only orphans and destitute children of mixed parentage.

Our farm is right on the northwest corner of Nepal (in India). My wife and I are carrying on alone at present. We have three boys and two girls undergoing training. The girls are taught home making, gardening, and poultry keeping. At present it is still a purely mechanized farm, as without adequate buildings the tigers, leopards, etc, present a menace to livestock. Quite often at night the old tiger comes to the edge of the jungle about 150 yards from our tent and lets us known what he thinks of this encroachment on his domain, by filling the air with his protest.

We live in a tent with a dirt floor, and the only furniture we have was made from packing boxes. My wife takes care of our four children ranging in age from 8 years to 3 months; teaches the eight-year-old, helps train the girls, one of which has a baby 2 months old, and acts as my stenographer as well as farm manager when I am away, as I have been for almost the past month.

When I arrived in India, we assembled our John Deere "B" tractor, 14 x 7-ft Cobey wagon, and TVA thresher, and with the help of two Anglo-Indian boys, we drove our 40-ft caravan 1,000 miles over mountains, deserts, and rivers to our farm. Some trip!

If any of our friends in America want their machinery and equipment demonstrated in India the "American way," they may send me some samples, but should let me know beforehand. It has taken six months for me to clear some of my equipment, and it should be remembered that I have no organization or group backing me financially. This *is* pioneering in the real American way.

MAXTON D. STRONG

The Good Shepherd Farm
Tanakpur, U. P., India

The Grain Storage Problem in 1949

By William McArthur

THE grain storage problem as it confronts us today stems from three principal developments: (1) increased production of grain, (2) increased mechanization of farm operations, and (3) lack of expansion in storage facilities. During the war, our production of grain went rapidly into consumption. Since the war, most of our production in excess of domestic requirements has been exported. Now we are entering a period of reduced exports, and we have the problem of insufficient facilities for the storage of reserve supplies of grain in excess of domestic and foreign requirements.

During the last eight years little new storage has been built, and this only in part to replace worn-out facilities. Although grain production has increased enormously above prewar levels, we are still trying to operate storage capacity on the basis of prewar conditions. The disparity between grain storage requirements and available grain storage facilities must be dealt with promptly and effectively if we are to avoid serious difficulties in the handling of crops this year and in the years ahead, and in making our price support programs work.

Increased Production. The federal government call for all-out food production to meet wartime and postwar requirements greatly accelerated the longtime trend toward a higher level of grain production in the United States. Our total output of grain in 1948 was a record 6.9 billion bushels — over 2 billion bushels, or approximately 40 per cent, more than the prewar average. Our production of food grains alone was more than 50 per cent above the prewar average.

Production of corn in 1948, totaling 3,651 million bushels, was 1½ times the relatively small crop of 1947. It was 1,075 million bushels larger than the 1937-41 average prewar crop. Production in 1948 was on the second smallest acreage of corn grown in fifty years. The yield was a record average of 42.4 bu per harvested acre. The carry-over from the 1948 crop is expected to total more than 700 million bushels, as contrasted with only 126 million bushels a year earlier.

Wheat production in 1948 totaled 1,288 million bushels, and was second only to the 1947 record crop of 1,367 million bushels. The 1948 output was 430 million bushels larger than the prewar average. The yield of 18 bu per acre was the third largest on record. Record or near-record crops of soybeans, oats, grain sorghums, and other crops also were produced in 1948.

The large increase in grain production in 1948, coming at a time when foreign market outlets began to show signs of contraction, will be reflected in substantially larger carry-over stocks at the beginning of the 1949-50 crop year as contrasted with a year earlier. These carry-over stocks of all grains promise to establish an all-time high record. The carry-over of wheat, of approximately 300 million bushels, will be considerably less than the record carry-over of 631 million bushels in 1942, but the carry-over of corn is expected to exceed 700 million bushels as contrasted with the previous record of 688 million bushels in 1940.

This year of 1949 may be another banner year in grain production. Crop indications in June were for a record production of approximately 1,337 million bushels of wheat. The production of oats was indicated at 1,475 million bushels, and of barley 283 million bushels. Indications for other crops are not as yet available, but another large crop of corn is expected on the basis of farmers' planting intentions and the favorable planting and growing season thus far.

Increased Farm Mechanization. Great progress has been made through the years in the mechanical harvesting of grain. But this in turn has created new problems in the conditioning and storing of grain on farms. Harvesting in great volume usually means harvesting while the crop is too high in moisture content for safe storage on the farm or in commercial warehouses. In the harvesting of small grains, many farmers start their combines before the grain is thoroughly ripe, or too early in the morning, or when there is too much green growth. The great rush of combine harvesting has resulted in an annual amount of wheat in practically all areas going out of condition when stored. The wheat becomes "sick." This problem is particularly acute in eastern and southern states, where the humidity is high, and there are insufficient storage facilities for the increasing quantities of small grains which are being produced.

In the harvesting of corn with modern machinery, the problem of storage also has been accentuated. We know that mechanical corn pickers operate best before the corn becomes too dry. Farmers in northern areas try to get their corn picked before snow flies, and in states east of the Mississippi River the farmers want to remove the corn crop early so as to plant the land to winter wheat, barley, oats, and cover crops.

We are indebted to agricultural engineers for the progress that has been made in the artificial drying of ear corn during the past two years. I am told now that portable driers have been greatly improved by the use of jet burners which can provide a variable amount of heat through an internal-combustion chamber, and thus practically eliminate the fire hazard.

The improvement of portable driers and the construction of more suitable storage units will probably enable many farmers to properly condition and store corn which has been harvested early or which is high in moisture because of immaturity. However, many small farmers, particularly tenant farmers, will find it difficult to provide their own conditioning facilities, and there appears to be a great opportunity for the expansion of commercial grain-conditioning facilities in a large part of the marginal grain-producing areas.

Insect damage also has become an increasing problem resulting from the harvesting and storing of grain before the grain is thoroughly dry. Infestation of corn by the angumois moth seems to be unusually bad this year in Tennessee, Kentucky, southeast Missouri, southern Illinois, Indiana, and eastern states, and the Commodity Credit Corporation is now taking delivery of several million bushels of corn from this area, under its price support program. More investigation and development work needs to be done in the proper storage and conditioning of grain in the heavy insect-infestation areas, where producers are suffering great financial loss because of their inability to store the grain and avail themselves of price support in carrying out an orderly marketing program.

Inadequate Storage. There has been an appreciable increase in farm grain storage facilities during the last few years, but the total capacity of existing facilities probably does not significantly exceed that which was in existence before the war. Existing facilities were allowed to deteriorate during the war, when farmers' total efforts were directed toward the all-out production of food to meet wartime requirements. Moreover, shortages of labor and materials precluded the expansion of farm and commercial storage facilities. There was hardly enough building material available for the maintenance of existing facilities and for replacements, to say nothing of the building of additional facilities.

Our storage requirements are much larger now than they were before the war. Although the United States is now supplying more than half the world exports of grain, we expect to have a record carry-over of grain this year. This grain must be properly stored against current and future requirements here at home and abroad. A substantial part of the carry-over from last year's crops will be delivered to the Commodity Credit Corporation in fulfilment of price support loans and purchase agreements. At the same time, large crops of grain are coming out of their (Continued on page 376)

This paper was presented at the annual meeting of the American Society of Agricultural Engineers at East Lansing, Mich., June, 1949, as a contribution of the Farm Structures Division.

WILLIAM MCARTHUR is assistant director, grain branch, Production and Marketing Administration, U. S. Department of Agriculture, Washington, D. C.

Hydraulic Circuits for Farm Tractors

By Joseph F. Ziskal

THE advantages of hydraulic power to lift tractor-mounted or direct-connected farm implements need not be pointed out to the agricultural engineer. Most engineers are familiar with the necessity of hydraulic power to operate farm implements and some excellent discussions on the subject have been presented previously before this group.

Hydraulic and tractor engineers are constantly working toward the improvement of tractor hydraulic systems to increase the efficiency of the hydraulic unit and to still further increase the utility of the system for the operation of farm implements. Some important contributions have been made in this direction in recent years.

There are a number of good hydraulic systems in use on farm tractors today, and it is not the intention to cover all of these circuits in the time allotted, but I would like to describe some of the earlier circuits and some of the new circuits that engineers of the International Harvester Company have developed in their efforts to provide better and more convenient operation of farm equipment by our customers.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Power and Machinery Division.

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The first hydraulic circuit consisted of a pump, a safety valve, a reservoir, a control valve, and a cylinder connected to the valve with hoses. The system had no by-pass and kept operating at about 300 psi. This of course wasted engine power, heated the oil and lowered the efficiency of the pump to a point where the system became inoperative.

Engineers then concentrated on means of relieving pressure on the oil during the non-working cycle in order to maintain a low temperature and high efficiency. Numerous methods were devised, such as a separate by-pass valve, an open-center-type valve, disengagement of the pump, blocking of the pump intake, and use of a variable-displacement pump which did not pump during the non-working periods. With the oil

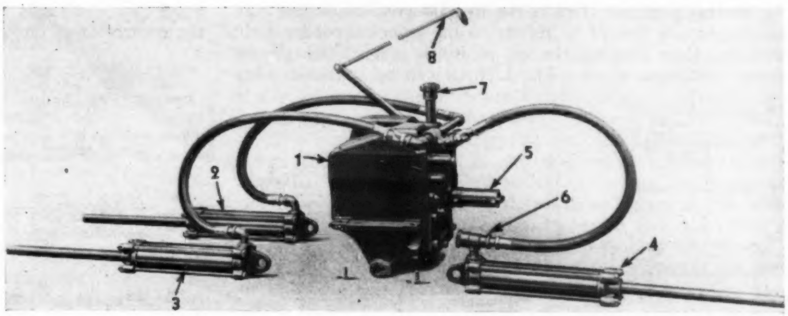
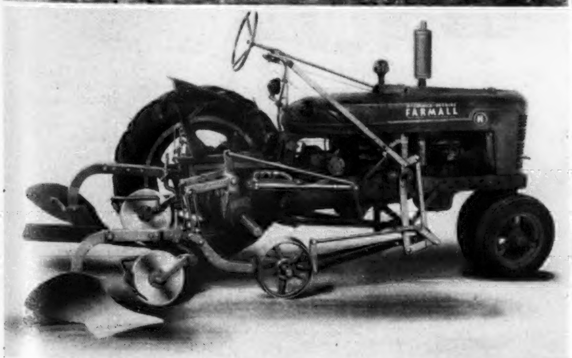


Fig. 1 The International Harvester "Lift-All" hydraulic system assembly used on Farmall H and M tractors: (1) pump unit, (2) right-hand front power cylinder, (3) left-hand front power cylinder, (4) rear power cylinder, (5) coupling which connects with tractor power take-off drive, (6) delayed-lift valve, (7) oil filler, (8) control rod



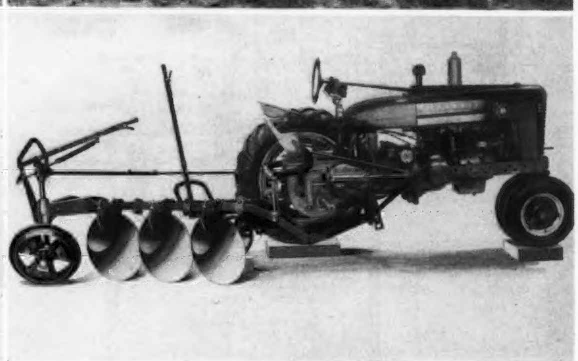


Fig. 2 (*Upper left*) Cultivator with delayed lift entering a cornfield • Fig. 3 (*Upper right*) Cultivator with delayed lift coming out of corn field • Fig. 4 (*Lower left*) A two-way moldboard plow with Lift-All. (Tractor drivewheel removed) • Fig. 5 (*Lower right*) Disk plow with Lift-All. (Tractor drivewheel removed)

temperature kept at a minimum during the by-pass cycle, it was possible to use higher working pressures. Prior to World War II, many systems were working at 800 to 1,000 psi.

A good example of this is provided by the hydraulic system (Fig. 1) on Farmall H and M tractors, known as the "Lift-All".

Figs. 2 to 5 show various implements mounted on the tractors, with Lift-All cylinders operating the implements. A noteworthy feature of the Lift-All is known as "delayed lift". It is used principally with forward-mounted and rear-mounted cultivators. As the tractor comes to the end of the crop row, the operator moves the control lever and the forward-mounted gang is lifted out of the ground immediately. Lifting of the rear-mounted gang is delayed just long enough to let it finish cultivating the row. When the tractor starts into a row, the action is reversed. The forward-mounted gang enters the ground first, followed by the rear-mounted gang a second later. This is a popular feature.

Fig. 6 shows the Lift-All system with the control lever in the neutral position. This is the by-pass position of the unit, which permits the oil to return to the reservoir under light pressure, thus keeping the oil relatively cool although the pump continues to run. The Lift-All can be operated when the tractor is in motion or when the gearshift lever is in the neutral position, inasmuch as the pump drive is taken back of the engine clutch.

Fig. 7 shows the control lever in the raising position. It is held in this position (D) by the locking lever, which drops into a step portion on the control lever. With the control lever in this position, the piston closes the by-pass opening, and the oil, under full pressure, opens the ball check valves and goes to the front power cylinders. As soon as the front power cylinders have completed their stroke, or for some other reason the pressure builds up to 500 psi, the delayed-lift valve opens, allowing oil to enter the rear power cylinder.

In Fig. 8 the front cylinders have been filled and the oil pressure, having risen above 500 psi a moment later, has forced open the delayed-lift valve, allowing the rear cylinder to fill. The slight delay in filling the rear cylinder permits the front section of the cultivator to raise first, which is what the operator desires as he comes to the end of the row. When the rear cylinder is filled, the oil pressure pops the relief valve cap and raises the locking lever. This in turn releases the control lever latch and the system goes to a neutral posi-

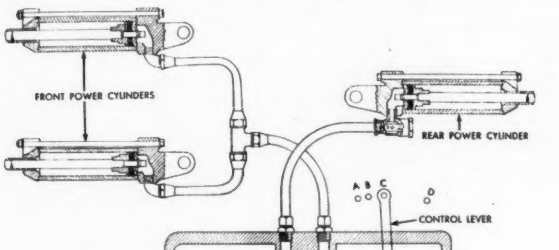


Fig. 6 Schematic diagram of Lift-All hydraulic system with control lever in neutral position

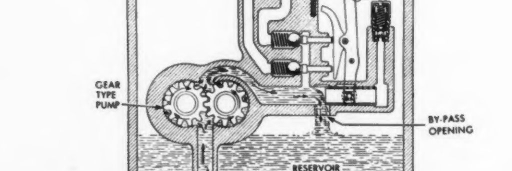


Fig. 7 Schematic diagram of Lift-All system with control lever in raising position

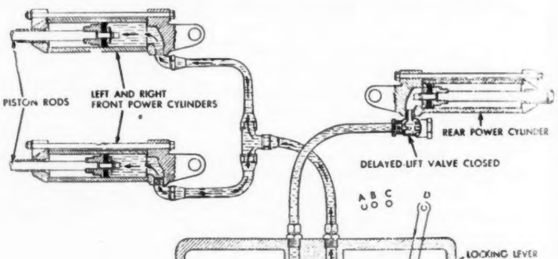


Fig. 8 Schematic diagram of Lift-All system with control lever moved from raised position (D) to neutral position (C)

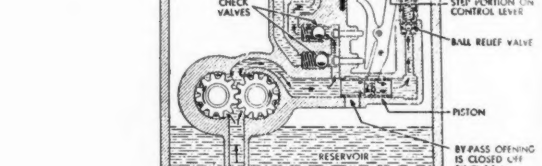


Fig. 9 Schematic diagram of Lift-All system with control lever moved to B. Oil pressure is released in the front power cylinders, permitting the front section of the implement to be lowered independently of the rear section

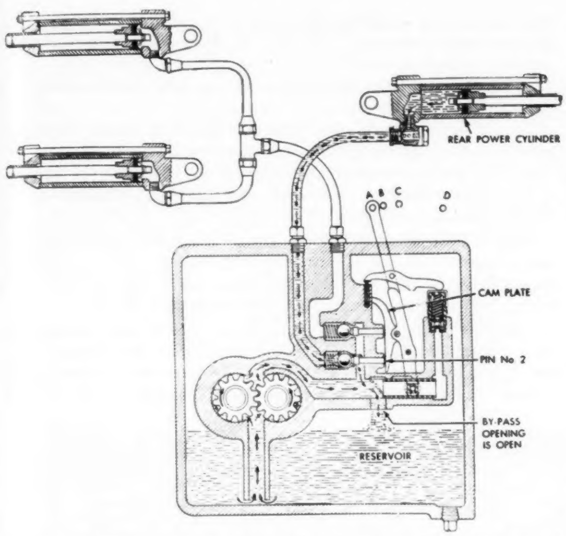


Fig. 10 Schematic diagram of Lift-All system with control lever moved to A. This releases oil pressure from the rear cylinder, allowing the rear section to be lowered

tion, with the check balls holding the cylinders full.

Fig. 9 shows the control valve moved to position B. In this position the ball check is released, which allows the oil to flow from the front cylinders to the reservoir.

Fig. 10 shows the control lever moved to position A, which releases the ball check holding the oil in the rear cylinder.

The working pressure of the Lift-All system is 750 to 800 psi.

World War II stepped up development in hydraulic pumps, seals, and hoses to a point where pressures up to 3,000 psi could be used safely. The doughnut or 0 ring-type of packing was developed to ease the seal and gasket problem.

While the Lift-All was originally developed for use with direct-connected implements, it is interesting to note the versatility of this system is such that it can be readily adapted to operate trailing implements as well.

This system has a gear pump mounted on the engine and driven from the front timing gears. A manifold is connected to the reservoir. The reservoir has a high-pressure communication to the control valve which is of the open-center type. The control valve is connected by hoses to the double-action cylinder which is of the depth-control type.

The oil circulates through the center of the valve and back to the reservoir during the by-pass cycle. When the valve is moved up or down, the oil is directed to one side or the other of the piston in the cylinder, exhausting the oil from the opposite side. The control valve is self-centering, and the instant the hand lever is released, the valve moves to the neutral position, holding the oil locked in the cylinder and by-passing the oil from the pump.

The operating position of the implement is controlled by means of the adjustable hydraulic stop valve. This valve, which is in the cylinder, is open while oil is being forced into the large or left side of the piston. When the piston is being retracted into the cylinder, the stop valve limits the length of piston stroke in accordance with the position of the adjustable stop-valve actuator on the piston rod.

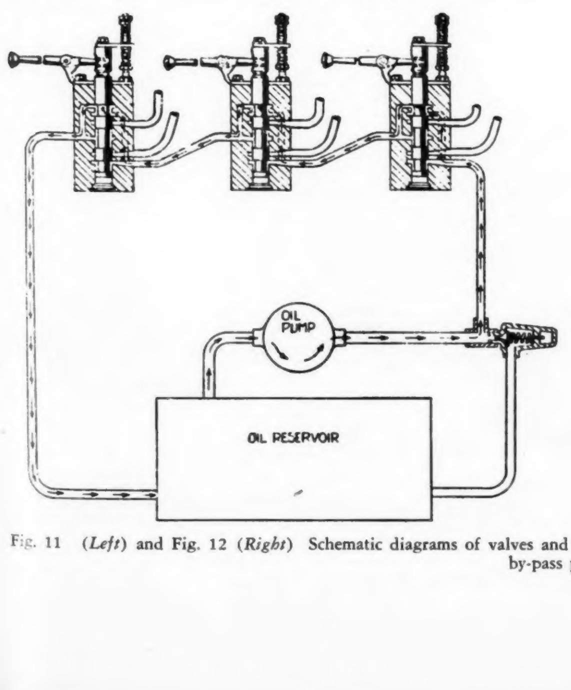
It is also possible to use a mechanical stop on the cylinder for implement control.

In the system illustrated (Figs. 6 to 10) the pump, reservoir, and control valve are mounted on the tractor, but the cylinder is mounted on the trailing implement. To protect the hoses in case the hitch breaks or is released, a self-sealing breakaway coupling can be used.

The circuit shown in Figs. 11 and 12 is quite interesting, inasmuch as the pistons in any number of cylinders can be moved at the same speed, regardless of unequal loads imposed on the piston rods. Fig. 11 shows three valves in the open-center, by-pass position. The movement of any one valve, up or down, causes a corresponding movement of the piston in the cylinder which it controls. When simultaneous operation of two or more cylinders is required, it is necessary to move all valves. This causes the pistons in the cylinders to move at the same speed. The second and third cylinders operate as slave cylinders deriving their power from the first cylinder. This may have some disadvantages, but there are also advantages since, in the conventional system with two or more cylinders in parallel, the cylinder with the smaller load always moves first.

In reviewing all the previously described circuits, it is obvious that in each case, when the operator wanted positive implement control, he had to adjust levers and sometimes he had to get off the tractor to do so.

As a postwar project, Harvester engineers designed a new hydraulic system for the operation of direct-mounted implements. This system was designed to lower the implement



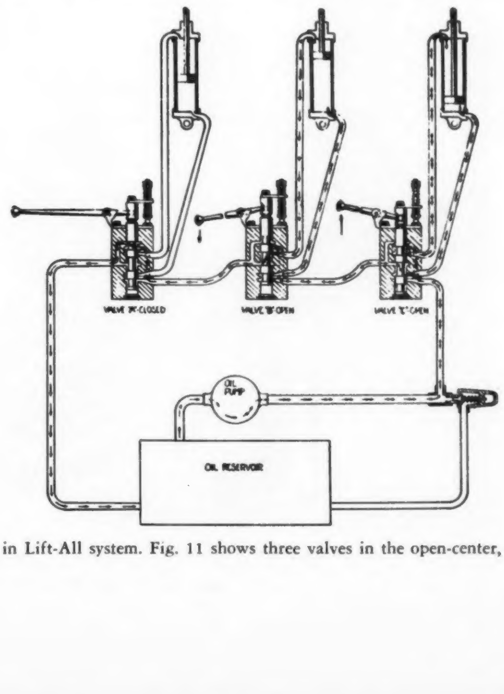


Fig. 11 (*Left*) and Fig. 12 (*Right*) Schematic diagrams of valves and cylinders in Lift-All system. Fig. 11 shows three valves in the open-center, by-pass position

under power as well as to raise it, and to hold it automatically in whatever position the operator set it. With its selective control feature, it has been especially valuable in cultivating point rows, crossing grassed waterways, working in small fields, and on terraced land where change of implement position is frequent.

This new hydraulic system, which we call "Touch Control," has the following features:

1 It consists of one major unit comprising two double-action cylinders, each connected to a rockshaft with a power arm on each side of the tractor and mounted amidship on the tractor. By connecting the implement lift rods to the inner or outer rockshaft arms, either delayed or selective lift of the implement can be obtained.

2 The pump is mounted on the engine, making the hydraulic power available whenever the engine is running, regardless of the position of the clutch.

3 It is fast, providing a full throw of the power arm in one second and enabling the operator to control the implement almost instantaneously and thus to keep both hands on the steering wheel while turning.

4 It lifts about 2,000 lb through an 8-in stroke and holds the load indefinitely.

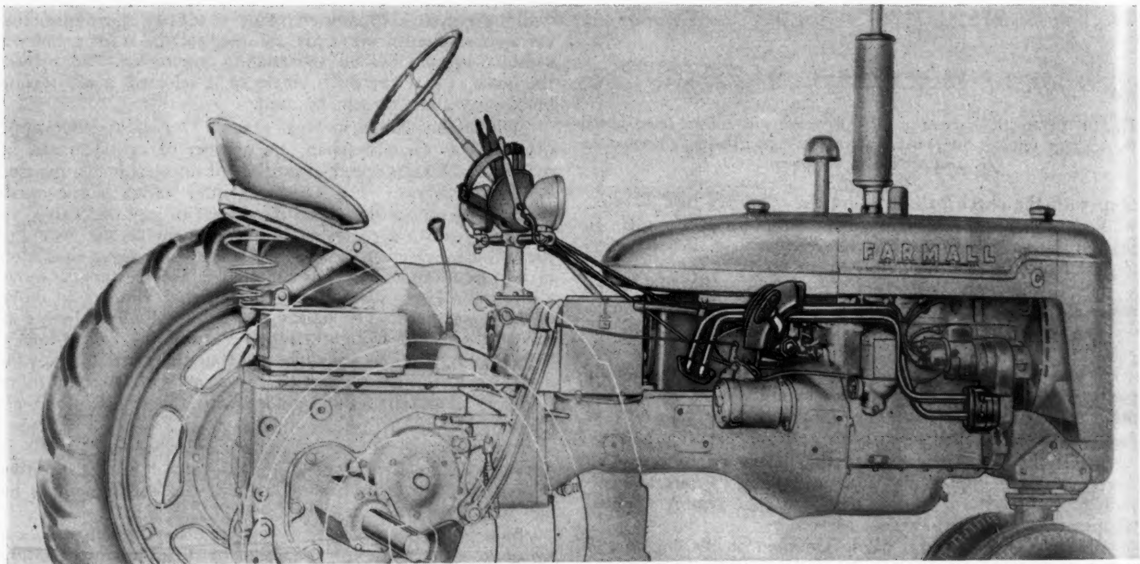
5 It is a follow-up system, requiring only finger-tip effort on the control levers, regardless of load.

6 There are no hose connections anywhere in the system.

7 It gives power control for any operating position of the implement at all times.

Fig. 13 shows the Touch Control hydraulic unit mounted on a tractor, with the pump on the engine and a manifold connecting the pump to the hydraulic unit. Fig. 14 is a cut-away view of the Touch Control hydraulic unit.

Fig. 15 is a schematic drawing of the Touch Control in the neutral position. Whenever the engine is running and the control levers (1) are stationary, the two slide-control valves (2) block the passages from the pump (4) to the



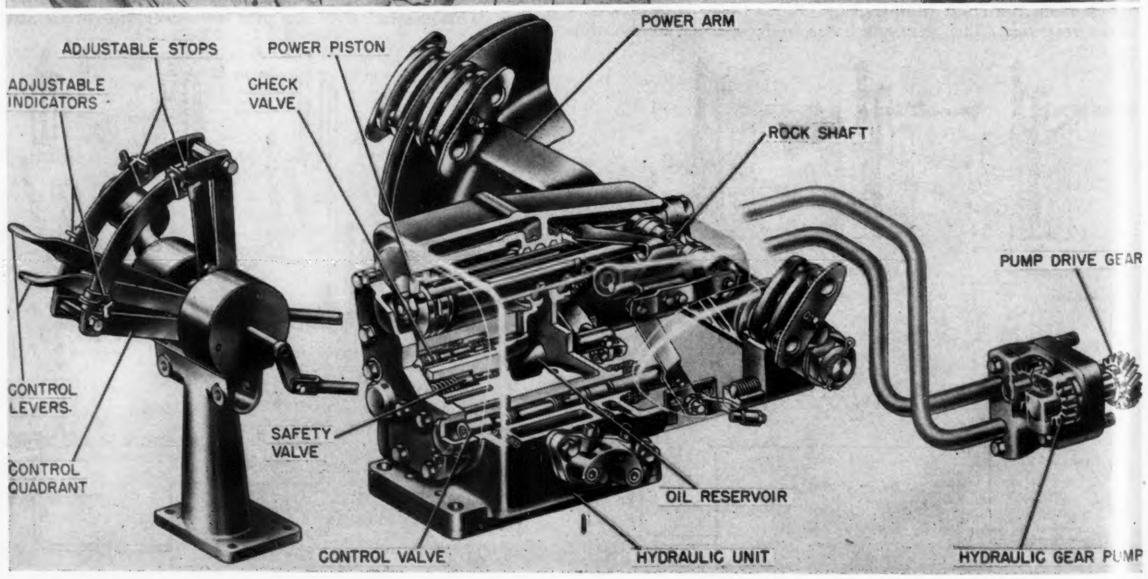


Fig. 13 (*Top*) International Harvester Touch Control hydraulic unit mounted on a tractor • Fig. 14 (*Bottom*) A cutaway view of the Touch Control unit

check valves (3) and to both sides of the power piston (5). As soon as the engine starts, the oil from the pump starts to apply pressure on the system. Since the passages are closed to the power pistons (5), pressure is applied through the regulator-valve orifice (6) on the regulator-valve piston (7) circuit. This slight pressure (32 psi) moves the regulator-valve ball (8) off its seat and opens up a free passage for the oil to flow through the valve. The oil is then by-passed directly to the reservoir (9). Since the regulator-valve piston (7) has four times the area of the valve ball (8), it easily opens and holds the ball off its seat. The oil circulates in this manner until one or both of the control levers are moved.

Fig. 16 shows a schematic drawing of the Touch Control unit during a power cycle. In the lifting operation, the forward movement of the lower control lever (1) moves the slide control (2) forward. This opens passages for three circuits of oil (A, B, and C) as follows: (A) The regulator-valve piston (7) circuit is free to flow into the return oil circuit which instantly relieves the pressure on the regulator-valve piston (7) and causes the regulator-valve ball (8) to seat. A small quantity of oil continuously passes through the regulating-valve orifice (6) and by-passes to the oil reservoir (9). (B) The oil from the pump (4) now pushes the first check valve (3) off its seat and applies the necessary pressure (up to 1200 psi) on the head of the power piston (5). (C) The instant the pressure starts to build up to move the power piston (5), this pressure also moves the actuator piston in the upper check valve (3) and forces the valve off its seat. As

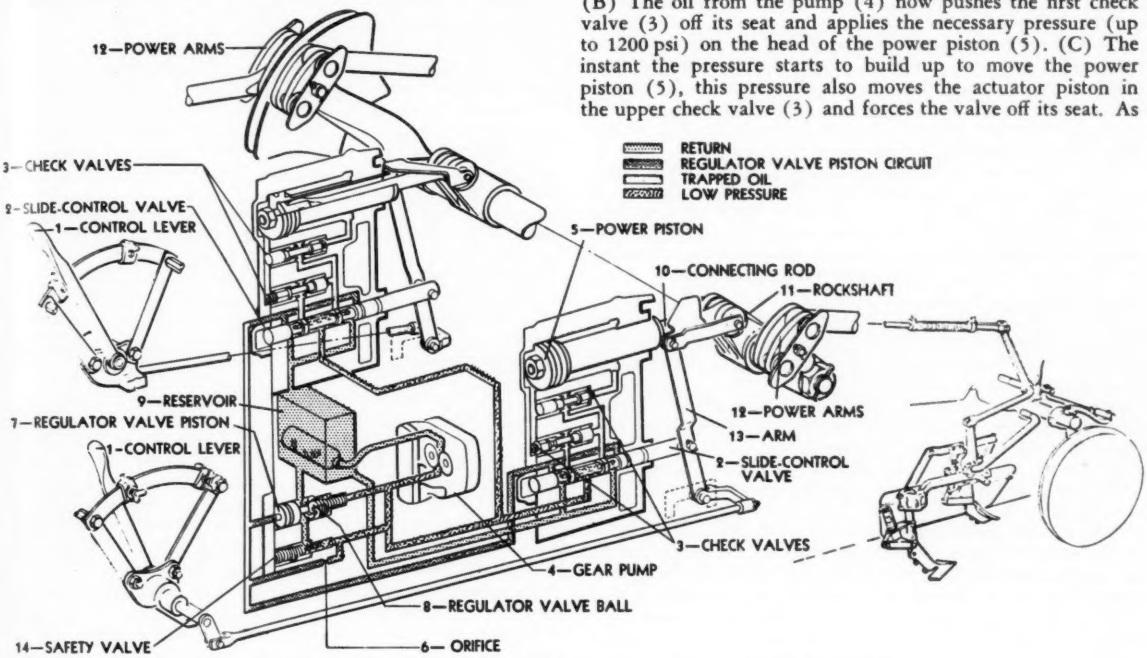


Fig. 15 A schematic drawing of the Touch Control unit in the neutral position

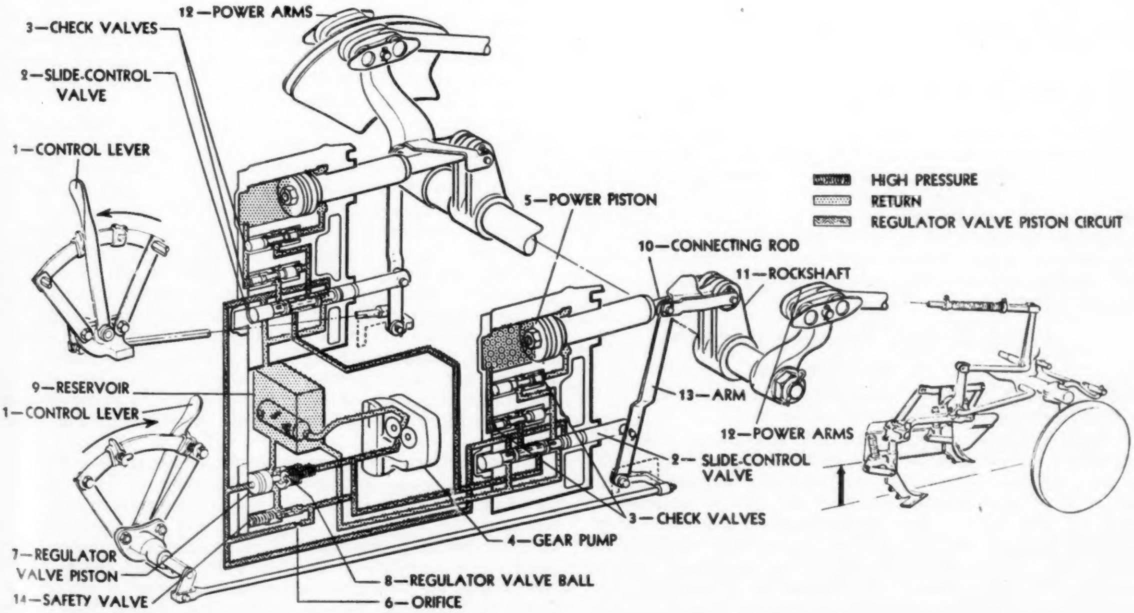


Fig. 16 A schematic drawing of the Touch Control unit during a power cycle

the power piston (5) is moved, the oil previously locked on the back side of the piston now flows back to the oil reservoir (9).

The piston (5) starts to move the instant the control lever is moved. As soon as the control lever is stopped, or reaches a preset position, a response mechanism, consisting of a beam-type arm (13) connected to the slide control valve (2) and the rockshaft (11) returns the slide control valve (2) to the neutral position when the piston (5) has moved the distance corresponding to the movement of the lever (1). The check valves (3) then automatically return to their seats and positively lock the piston (5). Simultaneously, the regulator-valve piston (7) opens the regulator valve (8) which again permits the oil to by-pass to the reservoir.

In the lowering operation, the control lever is moved to the rear. This moves the slide control valve to the opposite direction and reverses the flow of oil to the power piston. Pressure is applied to the opposite side of the piston, which forces it back into the cylinder and permits the oil on the other side to return to the reservoir.

A safety valve (14) is provided in the hydraulic system to protect it against excessively heavy loads. The valve opens at a pressure of 1200 psi. The Touch Control levers can be moved slowly a short distance and stopped anywhere on the quadrant to obtain precision operating adjustments. They also can be moved quickly all the way forward or back to lower or raise implements instantly.

When the Touch Control levers are stationary and the system is in neutral, oil is trapped on both sides of the power piston by the check valves (3), thereby firmly holding the implement in any position.

In this system there is no perceptible change in hand lever effort due to load variation. The control valve, being balanced, has the same ease of movement at all times and the check valves, being operated only by oil pressure, provide a safety factor which is very important in the operation of farm machinery.

The check valves cannot be operated by the movement of the control valve unless the engine is running. Therefore, with the engine shut off, the lift is inoperative regardless of movement of the control levers. The load will stay in position and children who might play with the control levers would not be hurt. In the case of the cutter bar on a mower, this feature is very important from the safety angle.

The problem of providing a satisfactory tractor hydraulic system is a difficult one. The unit must be compact and located to facilitate design of mounted implements and not interfere with the operator's vision when cultivating narrow rows.

Safety, simplicity, ruggedness, and good appearance — these are all important considerations in farm machine design, but we must also remember the cost angle. In our efforts to ease the farmer's work, we should not develop equipment which must be priced beyond his reach. Hydraulic equipment could easily graduate to the gadget stage and be too expensive for the farmer to buy, regardless of its advantages. We must hold hydraulics for farm application to a practical design in which safety, low first cost, and reasonable maintenance cost are prime considerations. I think it is safe to predict that in the not too distant future you will see hydraulic control mechanisms applied to the operation of every major piece of farm machinery.

Grain Storage Problem in 1949

(Continued from page 370)

year's harvests, and large quantities of these also need to be stored safely against current and future needs.

Despite record exports in 1948-49, amounting to approximately 18 million tons as contrasted with 15 million in each of the preceding two years — the remaining supplies of grain are so large that emergency action has had to be taken to store old-crop grain so as to make room for the new harvest. Airplane hangars, war plants, and many other facilities are being used for temporary storage. Some grain also may be stored in the laid-up fleet in the Hudson River, and consideration is being given the possibility of overseas storage in occupied areas.

Farmers have been encouraged to reseal wheat, oats, barley, and corn on farms for another year, through appropriate storage payments which will assist them in acquiring additional storage facilities. This resealing program imposes an obligation upon the government to assist farmers in expanding their grain storage facilities and to provide adequate storage for the supplies which are delivered to the Commodity Credit Corporation.

The 1949 winter wheat crop is now being harvested in the Southwest. The harvest is so large that many farmers have been unable to find suitable storage for their grain. To help relieve this situation, the Department of Agriculture recently announced an emergency program in which the CCC will grant "distress" loans for wheat stored for a short time in the open or in temporary storage facilities, pending storage in more permanent structures. The "distress" loans amount to 75 per cent of the regular loan rates, the balance of the full-price support loan to be paid when the grain has been put into adequate storage facilities. Determination of grade and quality will be made at the time the grain is put under the distress loan.

In areas where it is not practicable to leave wheat in the open or in other temporary storage and where adequate storage facilities are not available, the CCC itself will undertake to provide suitable emergency storage and will use government-owned war surplus facilities where available or take other special measures to get the wheat under cover. This will make it possible for farmers in such areas to take advantage of the distress loan provisions.

LOANS ON NEW FARM STORAGE BINS

The Department has also announced that in order to assist farmers in providing adequate farm storage facilities, the CCC will lend farmers to the extent of 85 per cent (but not more than 45 cents a bushel) of the cost of purchasing or constructing new farm storage bins. These loans bearing interest at the rate of 4 per cent will be payable in five annual installments or earlier at the farmer's option. The loans may be made by banks or by CCC direct.

In order to be in position to take over and provide storage for grain delivered to CCC under price support programs, and to provide for carrying over a part of the necessary reserve supply of grain in the national interest, the CCC may also contract for storage facilities to be placed on leased or purchased sites at strategic points throughout the country to the extent that other facilities are not available. The CCC at the present time owns approximately 45 million bushels' capacity of bin-type storage. It is believed that an additional 50 million bushels of comparable storage facilities properly located would materially assist in alleviating the storage problems which are expected to arise this year.

Considering the over-all grain storage situation, there is definite need for more elevator-type storage to handle grain supplies efficiently in the years ahead. It is expected that co-operative and other commercial interests, recognizing the future storage requirements, will start the necessary construction programs through established channels of private initiative

In carrying out a program of expanding farm and commercial grain storage facilities every effort should be made to see that full use is made of the results of research in the field of grain storage and grain conditioning, in order to provide the widespread adoption of advanced designs of storage structures adaptable for use in conjunction with modern drying and handling equipment. In this connection, we greatly appreciate the work of agricultural engineers in developing plans for the widespread distribution of information on these subjects.

The development of adequate grain storage is a part of our total program for balanced abundance of food. It can facilitate the administration of acreage allotments and marketing quotas when these are needed to adjust production to consumption requirements. It is indispensable in making our price support programs effective. Price support can be effective only as we have sufficient storage facilities on and off the farms to enable farmers to handle and market their grain in an orderly way.

The Storage of Sugar Beets

By C. M. Hansen
MEMBER A.S.A.E.

THE problem of storing sugar beets at the processing plant with minimum sugar loss has long been recognized in the eastern sugar beet growing area. The acceptance of the beet harvester has made this problem more acute, for the farmer wants to deliver his beets as rapidly as he can harvest them. Consequently proper means must be found to receive and store the beets until such time as they can be processed. Often the storage time is marked by periods during which the temperatures do not go below 65 F Data collected by Stout and Fort* shows that beets stockpiled during such warm periods will lose sugar at the rate of 1/4 to 1 lb per ton per day, depending upon the prevailing temperature. In the eastern area alone, the yearly loss amounts to about $1,500,000. Further importance is attached to this problem when one considers that plant breeders require three to five years of work to develop a beet variety having an increased sugar content of only one per cent. It is indeed urgent that the beets be given the utmost care during harvest from the ground to the processing plant.

During the past two years the agricultural engineering department of Michigan State College has been carrying on experiments in which various economically feasible methods of storing beets commercially were considered. For the purpose of this paper, only important phases of this work will be touched upon.

The storage tests were performed in six bins housed in an open shed which has a roof high enough to permit free circulation of air over the top of the beets. The bins were 6 by 10 ft by 8 ft high, having a capacity of approximately 10 tons of beets. Heavy wire screen was laid over joists 3 ft above ground, making it possible to force air through the bins from the bottom. Building paper was used to seal the sides of the bins, also the bottoms of the "check" treatment bins. Each bin was equipped to receive any metered quantity of air through ducts from a plenum chamber which was fed by a 1000-cfm backward curved-blade blower. The blower was operated during the night hours, from 6 p.m. to 6 a.m. The air was accurately measured with a manometer after each bin was filled. Initial calculation showed that it was not necessary to correct the quantity of air to the barometer and relative humidity.

Temperatures were obtained by means of an electronic recording potentiometer and copper constantan thermocouples. All thermocouples were calibrated in a stirred water bath and found to be correct to a ± 0.4 F. Each bin had 16 thermocouples placed in four layers 18 in apart, starting 18 in from the bottom. Two thermocouples in each layer were placed into the center of beets and the other two recorded the air temperatures of the interstices. Ambient air temperatures and the data pertaining to the relative humidity of the air entering and leaving the bins were also secured by means of the recording potentiometer.

Beets which were used in the experiment were harvested by the lifter-topper-type machine, the most widely used mechanical harvester in the eastern area. The freshly harvested beets were hauled from the weighing station after they had been run over the piling equipment. An effort was made to obtain beets having uniform size and they were tared as they entered the bin. The tare differences were less than 0.5 per cent. Ten random selected beet samples for sugar analysis were taken at regular depth intervals as the bins were filled.

When the bins were unloaded at the conclusion of the experiment, care was again taken to select the beets for sugar analysis from the same levels and locations where the original samples were taken.

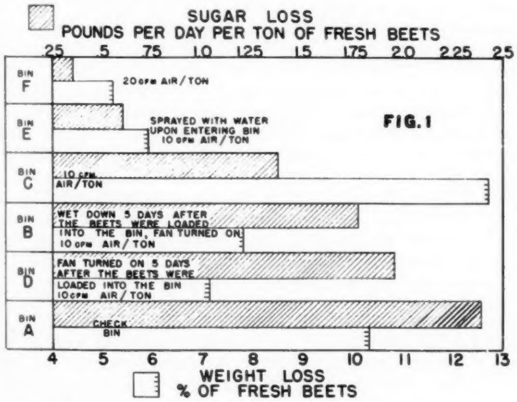
Beets for each bin were accurately weighed immediately before binning and again at the conclusion of the experiments in order to determine shrinkage in weight.

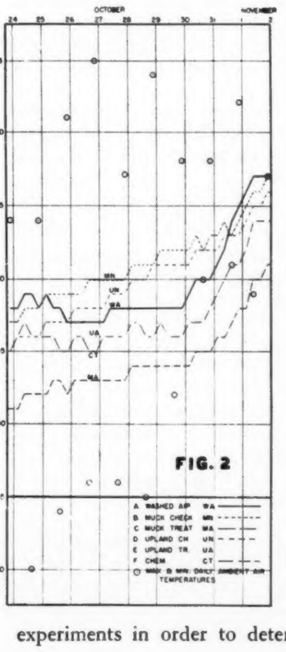
This paper was prepared expressly for AGRICULTURAL ENGINEERING.

C. M. HANSEN is assistant professor of agricultural engineering, Michigan State College, East Lansing.

AUTHOR'S NOTE: Acknowledgment is made of the substantial help given by M. Frakes, agricultural research supervisor, Michigan Sugar Co.

* Stout, M. A. and Fort, C. A. Respiratory Heat of Sugar Beets and Its Influence on the Practical Harvesting and Storage Problem. The U. & I. Cultivator, October, 1946, 11-13.





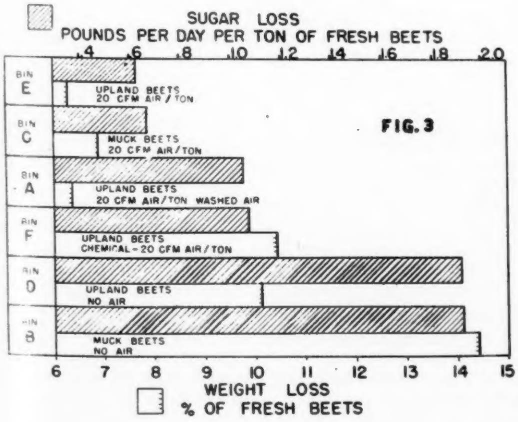


Fig. 1 Results as to sugar and weight losses for the 1947 sugar beet storage experiment. The loss in sugar is not proportional to the loss in the weight of beets • Fig. 2 This chart shows temperatures representative of those obtained during the 1948 experiments • Fig. 3 Data pertaining to the 1948 experiment. The treatments in which ambient air was forced through the beets at the rate of 20 cfm per ton of beets gave the best results of the two years' experiments

THE 1947 EXPERIMENT

All of the beets used for the 1947 experiment were grown on mineral soil. The beets were held in storage for only 21 days, due to the fact that the work began late in the season. The following treatments were given to individual lots of beets:

(a) Check. The bin used for this purpose was sealed with building paper leaving only the top open.

(b) The beets were wet down with water five days after binning. Air at the rate of 10 cfm per ton of beets was then forced through the beets for each successive night the blower was in operation. The quantity of water was not ascertained but enough was poured over the bin to run freely from the drain at the bottom. This procedure was repeated on the seventh and ninth days of the experiment.

(c) The beets in the treatment were subjected to 10 cfm of air per ton of beets.

(d) Five days after binning the beets in this treatment were given 10 cfm of air per ton of beets. This treatment was to demonstrate whether or not a bin of beets could be brought under control after respiratory action had passed through a number of cycles.

(e) The beets were sprayed with water as they were binned. The quantity of water was not recorded, yet there was no apparent excess after gravitational water had run free. The purpose of this treatment was to determine whether or not it would be possible to evaporate moisture from the beet surfaces to give a beneficial cooling effect. The washing operation did remove some dirt, the weight of which was accounted for by a tare figure. Air at the rate of 10 cfm per ton of beets was forced through the beets.

(f) The only difference between this treatment and the treatment c was that the quantity of air was doubled.

Discussion of 1947 Results. The criteria for evaluating the results of the experiment is the number of pounds of sugar saved per ton of fresh beets; but before considering these data some attention might be given the factors causing differences in sugar losses.

The trash deposits of the treatments were approximately equal, as indicated by the tare data. In the case of the forced-air treatments, these "localized" deposits limited the flow of air above them causing excessive decay. In both treatments where moisture was added this decay was extensive.

It is quite evident that any method requiring the addition of water in any form is harmful to beets. Some initial cooling was accomplished by spraying the beets with water as they were binned, but the bin temperature rose on the second day and remained above the bin temperature of the most successful treatment, e.

In the case of treatment b, in which the beets were wet down at three different intervals, the added moisture caused excessive top growth and decay occurred where there was a trash pocket. This seriously reduced the available sugar.

The beets which received 10 cfm of air per ton did not keep well, but the treatment in which they received 20 cfm proved to be most successful (Fig. 1).

Relative humidity of the air blown into a bin has much to do with the living processes of the beets. Calculations made as to the quantity of water vapor lost or retained by the air as it passed through the bin was found to be correlated with the weight loss of the beets. With air relative humidity over 80 per cent, and less than 60 per cent, excessive sugar loss was experienced.

Sugar loss was not proportionate to the loss in the weight of the beets due to tissue breakdown and excessive leaf growth.

Treatment f, in which the ambient air was forced into the beets at the rate of 20 cfm per ton of beets gave the most savings in sugar. It is also a treatment which would be economically feasible in industrial practices (Fig. 1).

THE 1948 EXPERIMENT

The 1948 sugar beet storage research program was set up in a manner designed to further check the accuracy of the 1947 data. Also the 1948 storage program included study of the keeping qualities of the beets grown on the organic muck soil for they have peculiar physical characteristics.

As a result of the previous year's research, it was decided to use 20 cfm per ton of beets in all of the forced-air treatments. The blower was again operated from 6:00 p.m. to 6:00 a.m., and the general procedure for the execution of the program was the same as in the previous year's experiments. The beets were held in storage for 36 days. Following is a description of the treatments given:

(a) The beets used for this treatment were grown on mineral soil and were given 20 cfm of 100 per cent relative humidity air per ton.

(b) Treatment b was designed as a check for the research pertaining to the storage of muck-grown beets. The bin was sealed on all sides and bottom with building paper, leaving only the top open.

(c) Treatment c was the same as the check treatment b, except that 20 cfm of ambient air per ton of beets were forced through the beets.

(d) A check treatment using beets grown on mineral soil. As in treatment b the bin sides and bottom were sealed with building paper.

(e) Treatment e was the same as check treatment d, except that 20 cfm of ambient air per ton of beets were forced into beets grown on mineral soil.

(f) Treatment f deviated from the others in that the beets were sprayed with a one per cent solution of orthophenylphenol, sodium salt as they were binned. An effort was made to coat the beet with the solution without carrying an excess of free moisture into the bin. Ambient air at the rate of 20 cfm per ton of beets was forced through the beets.

Discussion of 1948 Results. The difference in the keeping qualities of beets grown on mineral soils over those grown on organic muck soil is of no statistical importance, even though the beet grown on muck is conical in shape and harvests cleaner.

The temperatures of the beets were consistently uniform with no sharp variation throughout the course of the experiment. Using data obtained by Stout and Fort, it would have been possible to have predicted the order into which the treatments would fall as to sugar losses from the daily bin temperature graph (Fig. 2).

The treatments in which only ambient air was forced into the beets at the rate of 20 cfm per ton of beets gave the best results (Fig. 3). Weight losses are not proportional to sugar losses due to leaf growth and decay.

CONCLUSIONS AND RECOMMENDATIONS

There are a number of conclusions which one can draw from the data collected during the two-year program. In the light of these data there are a number of recommendations which might be made. The following are not necessarily in the order of their importance:

1 Trash deposits limit air flow causing excessive beet respiration. The result is tissue breakdown and subsequent heating. Trash and dirt must be kept at a minimum in the piles.

2 The optimum relative humidity of the air to be forced into sugar beet storage piles is approximately 80 per cent. It is not a wise procedure to force-ventilate a beet pile while it is raining, except in a critical case. Free water should not be permitted in the air ducts.

3 The temperatures of sugar beet storage piles should be checked at 4-hour intervals. The ambient air should be blown into the pile when it is 5 to 6 F colder than the hottest spot in the pile.

4 Initial cooling of the sugar beets in the storage pile is most desirable. This can be accomplished by blowing 20 to 30 cfm of ambient air per ton of beets into the pile until the beet temperature drops to 5 to 10 F about the mean daily temperature. Air at 10 cfm per ton will then be sufficient to maintain the pile.

Effect of Slope and Length of Run on Erosion Under Irrigation

By Stephen J. Mech
MEMBER A.S.A.E.

AN understanding of the influence of length and degree of slope has long been recognized as fundamental in any effective soil conservation program. It is hoped this paper on length of run and degree of slope will contribute to the information on the nature of this problem under furrow irrigation, also that this information will help in the understanding of the endlessly varying but basically similar problems that must be solved by the operations and extension worker.

That erosion is a serious problem under rainfall has long been an accepted fact. That it is a serious problem under irrigation is not so widely known. Those who have intimate knowledge of irrigated conditions are, however, deeply concerned. There are many who raise the very serious question as to whether irrigated agriculture in its present form is anything but a temporary land use. Dr. Israelsen[1]* in a lecture before the Utah State Agricultural College faculty stated, "An awakening of the American public to the fact that the permanence of agriculture in the arid regions depends vitally on more complete development of irrigation science in relation to erosion control on irrigated lands and to the solution of the alkali problem by more intelligent irrigation and drainage practice is evident." Both the erosion and the alkali problems are water induced. It is ironical that the water brought to give life to the desert lands should also be the means of destroying them.

A clearer picture of the intensity of the erosion problems under irrigation may be obtained perhaps by considering furrow irrigation in reverse. Instead of adding water to the soil by infiltration along the length of the furrow, let us invert the slope and permit the soil to yield water into the furrow at a rate equal to its infiltration rate. We would have the irrigation and erosion processes in reverse.

The runoff would be similar to that under precipitation. The extreme upper end would have very little flow and very little soil moving in the flow. The furrow flow would be increasing as it proceeds downhill until it would be equal to the application rate by the time it reaches the flume. In this reversed position the runoff and silt load would be more conspicuous and no doubt arouse considerable alarm. The fact that under furrow irrigation these occur in the opposite direction should not alter their potential hazard.

Early irrigation literature dealt almost exclusively with water and its relation to crop production. Occasionally an incidental reference was made to erosion or washing in the furrow. As irrigation became more widespread, the references to erosion and erosion damage became more frequent. In 1935 Taylor[2] reported results of an analysis and study on the influence of tillage on infiltration and erosion under furrow irrigation. In 1940 Taylor[3] reported on the relative transporting power of furrow streams. In 1940 a very comprehensive study of soil erosion in small irrigating furrows was initiated by Utah Agricultural Experiment Station. Results were reported by Israelsen, Clyde, and Lauritzen[4] in 1946.

The first attempt to measure erosion under irrigation, as far as I know, was initiated in 1937 on the Badger Pocket Demonstration Project near Ellensburg, Wash. The studies were conducted by the Soil Conservation Service in connection with the demonstration of better irrigation practices. Furrow streams were measured and volumetric measurements of soil loss were made along the furrows on potatoes for different slopes and length of furrows. Unpublished progress reports covering this work state "Investigations on the Badger Pocket area indicate that 20 to 75 per cent of the water applied to the fields was lost as waste water. Coincident with excessive amounts of waste runoff were soil losses of 30 to 60 tons per acre. On other fields serious erosion has occurred in furrows with deposition near the end, no actual field soil loss having been recorded."

The demand for additional information on the nature and magnitude of erosion under irrigation resulted in the establishment of the present research project at Prosser, Wash. in 1939. The work is conducted under a cooperative agreement between the Soil Conservation Service and the Washington Agricultural Experiment Station. The broad objective of this work is simply to find out how to add sufficient water to the soil for maximum crop production with the least amount of soil and water losses.

The limited amount of available information on erosion research under furrow irrigation made it necessary to pattern much of our earlier work after that conducted under rainfall conditions. It soon became evident that many of the concepts and techniques developed and used so successfully under rainfall conditions did not apply to furrow irrigation. In fact, some were seriously misleading. There was no raindrop impact. The problem was one of stream bank erosion. It mattered very little whether the space between the furrows was vegetated or bare. Increasing the infiltration increased instead of decreasing this eroding flow. The amount of erosion depended not on the over-all condition of the field, but on the condition in those narrow channels where the irrigating stream and furrow were in intimate contact. The condition away from these narrow strips had only a minor influence.

We found serious erosion on the upper end of irrigated fields even when neither soil nor water was lost from the lower end. With no soil lost from the bottom of the field, the conventional erosion measurement of "tons per acre lost from the bottom of the plot" was of very little value. In fact, the exceedingly low losses indicated by this technique may actually contribute toward a sense of false security. Under irrigation the soil loss, if expressed in tons per acre removed from the field, can be reduced and almost eliminated by simply increasing the length of the run. That erosion

Fig. 1 Layout of 300, 600, and 900-ft test plots for measuring erosion and flow along a furrow

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Soil and Water Division.

STEPHEN J. MECH is project supervisor, Division of Irrigation, Soil Conservation Service, U. S. Department of Agriculture.

*Superscript numbers refer to appended references.

can be so reduced is an obvious fallacy.

Erosion Along a 900-ft Run. It became necessary to find out what is occurring all along the entire furrow instead of merely getting a measurement at the end of the run. The end of the run under irrigation is, incidentally, a point where both the runoff and soil loss are less than anywhere else along the furrow. This is contrasted to rainfall conditions where the soil loss and runoff are usually greatest at the bottom of plots and decrease as the measuring point is moved uphill.

Plots to demonstrate and measure the variation of erosion along a furrow were laid out with a grade of 2 per cent in the irrigation channel (Fig. 1). Results are shown in Table 1.

TABLE 1. CHARACTERISTICS ALONG AN IRRIGATION FURROW

Distance from upper end of furrow, ft	Flow per furrow, gpm	Soil loss per furrow, lb.	Runoff, per cent	Travel time, hr-min: From point of application	Travel time, hr-min: For 300 ft distance
7.03 gpm per furrow applied 900 ft from bottom					
300	4.49	116	61	0-48	0-48
600	1.94	13	21	3-31	2-43
900	0.67	1	2	11-22	8-51
8.08 gpm per furrow applied 900 ft from bottom					
300	5.46	137	66	0-24	0-24
600	3.14	38	35	1-38	1-14
900	1.42	2	8	7-16	5-38

Soil and runoff measurements were made at points 300, 600, and 900 ft down from the top of the plots. The three plots in each test received identical application rates. For the first test 7.03 gpm was applied to each furrow. Since this application took over 11 hr to reach the lower end of the furrow, the rate was increased to 8.08 gpm for the second test. This required 8 hr, 51 min to travel the 900 ft. This too was longer than that usually recommended for efficient irrigation. Each test was made on a different set of plots, and each plot consisted of four furrows.

Results support the accepted maxim that the greatest erosion takes place where the flow of water is greatest. In furrow irrigation, however, the greatest flow is at the upper end of the run, and it is there that the greatest erosion takes place.

I wish to emphasize first that the results presented are for irrigation heads adjusted much finer than practicable, and second that considering the 900-ft run as a whole, the runoff and the soil losses at the bottom are negligible in both tests. Yet, when we consider what is occurring along selected portions of the furrow, it becomes evident that parts of it are subjected to severe runoff and erosion.

The upper third of these furrows, for example, is irrigated with an average runoff of 61 and 66 per cent. The soil losses at the bottom end of these 300-ft sections are 116 and 137 lb per furrow, respectively. The upper ends of these same

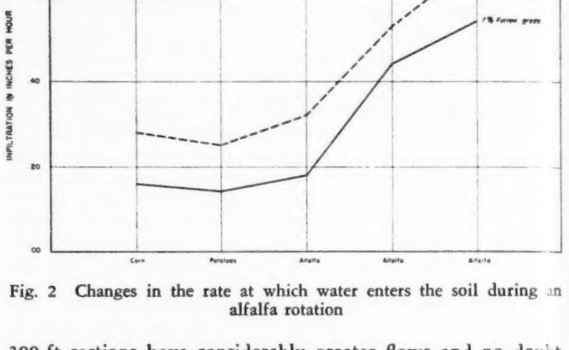


Fig. 2 Changes in the rate at which water enters the soil during an alfalfa rotation

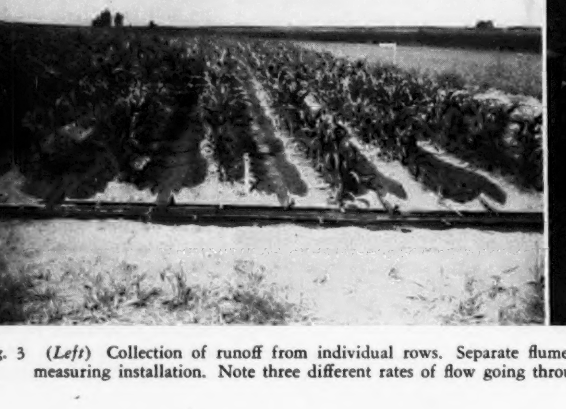
300-ft sections have considerably greater flows and no doubt had even greater erosion.

The middle third received a milder treatment. Yet here too, the soil loss and runoff are fairly high. The runoff from the first 300-ft became the application to the rest of the run. The erosion at the upper part of this section was identical with that on the lower end of the upper section. It amounted to 116 and 137 lb per furrow, while that at its lower end was 13 and 38 lb. The bottom 300 ft was subjected to a very small head and though the soil movement along this length was small, the effectiveness of the irrigation is considerably reduced by wide difference in the duration of wetting at the two ends.

From the above results it is evident that erosion measurements at the bottom end of the 900-ft plot furnished practically no information on what was occurring up the slope.

Results of this type of test have other applications. The three 300-ft sections present the erosion and runoff picture for a 300-ft run irrigated with (1) an excessively large irrigating head, (2) a medium large head, and (3) one adjusted very close to the infiltration rate of the furrow. In addition, by combining the top two adjacent sections, we have information on a 600-ft run irrigated with a runoff of 25 and 35 per cent. Combining the two lower sections shows what is happening on a 600-ft run irrigated with negligible runoff.

Influence of Flow on Erosion. The limitations of 900-ft plots for experimentation are obvious. Smaller experimental areas were more desirable. It seemed safe to assume that a given rate of stream flow would produce a certain amount of erosion at a given point, regardless of whether this flow was dropped into a tank at that point or was used to irrigate ad-



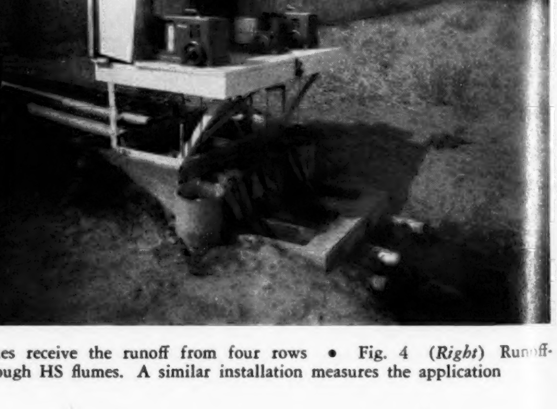


Fig. 3 (*Left*) Collection of runoff from individual rows. Separate flumes receive the runoff from four rows • Fig. 4 (*Right*) Runoff-measuring installation. Note three different rates of flow going through HS flumes. A similar installation measures the application

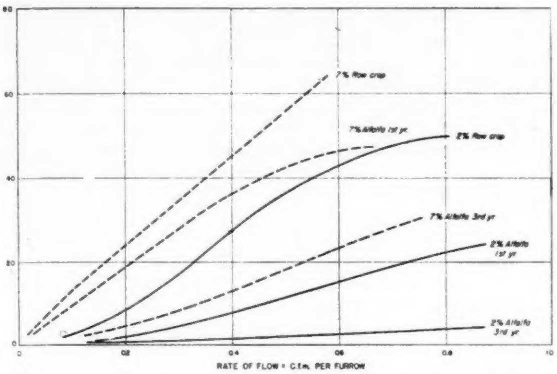


Fig. 5 Relationship of runoff rate and erosion. Erosion is the total and flow is the average for the irrigation season

itional land farther down slope. It was assumed also that the erosion caused by a given flow was independent of position along the furrow. Whether the 7.03 gpm application previously reported is used to irrigate a 900-ft run or is all taken up in a shorter run and greater infiltration, there will still be a soil loss of 137 lbs. at the point where the flow is reduced to 5.46 gpm. The problem for experimental purposes was resolved into the relationship of different stream sizes to infiltration and erosion for the crops as they occur in common rotations.

Two adjacent sets of plots 250-ft long were laid out on a 7 per cent slope on Sagemoor fine sandy loam soil. One set was irrigated straight down the steepest part of the slope and the other was irrigated in furrows directed across the same 7 per cent slope at a uniform grade of 2 per cent in the irrigating channel. This arrangement provided, in addition, information on the influence of furrow grade.

Automatic water-level recorders and type-HS flumes were used to measure the application and runoff. Erosion was measured by manual sampling at the bottom of the plots. It was assumed that the irrigating stream reached its silt-carrying capacity for the conditions of the test within the plot length. It was decided to use three rates of application, *q*, *2q*, *3q* and thus measure the influence of stream size on erosion and infiltration. Superimposed on each other, the three rates provided information on what is occurring at three points along a furrow 600 to 1,000 ft long.

The *q* rate was that application which would reach the end of the 250-ft furrow in about two hours. The *q* rate varied considerably between the plots with different furrow grades and to a lesser degree for the same plots during the season. Basically it was equal to the infiltration rate of the

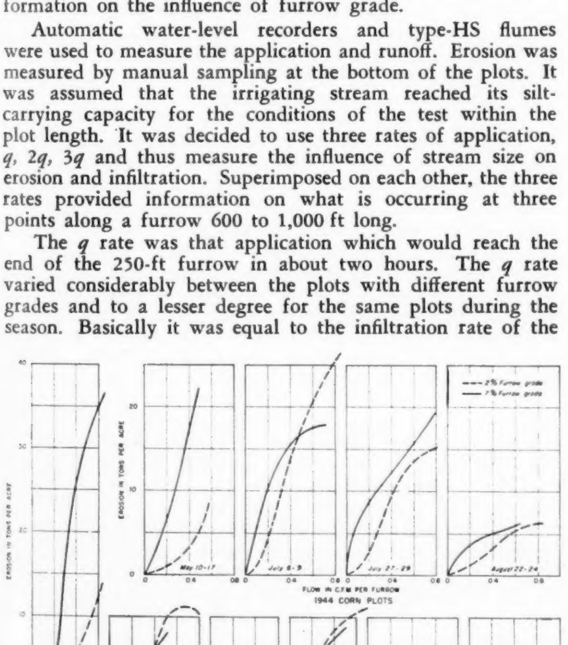


Fig. 7 Relationship between erosion per 250-ft plot and rate of flow. August 22-24 irrigation on corn and those on potatoes on June 25-27, July 24-26, and August 6-8 were made in furrows not disturbed after the previous irrigation

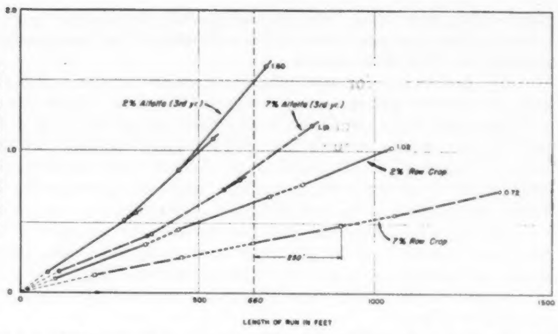


Fig. 6 Influence of crop and furrow grade on size of stream along the irrigation channel

plot plus a sustained trickle of runoff. For these short plots this trickle amounted to about 0.10 in per hr. The *2q* and *3q* rates were at all times, respectively, 2 and 3 times as great as *q*. Since the duration of application was the same for all three rates, the total amount of water applied to each plot was also in a ratio of 1: 2: 3.

The field used for this study was out of alfalfa for nine years. Part of it was seeded to alfalfa immediately, while corn followed by potatoes was grown on the other half the first two years of experimentation to find out what its irrigating characteristics were after being out of alfalfa for so many years. A fall seeding of alfalfa was made after the potatoes were harvested to study alfalfa's "soil-building" influence.

Though the yields were not much different from the three years of alfalfa (about 5 tons per acre each year), there was a great difference in the rate at which the soil took up the water. The average rate of infiltration for *q*, *2q*, and *3q* applications, expressed in surface inches over the entire plot area, jumped from 0.18 to 0.54 in per hr in three years' time on the 7 per cent slope and from 0.32 to 0.68 in per hr on the 2 per cent slope (Fig. 2). A stream of one second-foot was sufficient to irrigate 200 furrows on a slope of 7 per cent on first-year alfalfa, but the same flow was consumed by only 67 furrows during the third cutting year.

The rate at which the soil takes up water determined not only the number of furrows that could be irrigated with a given supply, but also governed the duration of the application. Potatoes required 7.1 hr irrigation to add one inch of water to the soil. The same field in three-year-old alfalfa was able to absorb one inch in only 1.8 hr.

Fig. 5 shows the relationship between the average rate of flow and season's erosion for row crops and alfalfa as measured at the bottom of the *q*, *2q*, *3q* plots. While this shows a relationship between erosion and flow, it is not a comparison of erosion on row crops and that on alfalfa. Nor does it compare erosion on a 2 per cent slope with that on a 7 per cent slope. It merely shows the ability of different rates of flow to pick up and carry soil for the crop and furrow conditions under consideration. To compare erosion it is necessary to find out first what the stream flows are under the conditions in question and then apply the erosion rates applicable to these flows.

Fig. 6 shows the actual flow measurements for row crop and alfalfa plots on grades of 2 and 7 per cent. The row crop data is the average of that from corn and potatoes, both of which were very similar. This graph was prepared by considering the *q*, *2q*, *and 3q* plot data as sections of a longer run. These curves are plotted so that the entire run is wetted but no runoff occurs. They show what the flow conditions are when the application is just equal to the infiltration. Moving the zero point to the right would show the flow conditions for different rates of runoff or tail water.

The solid portions of the curves are actual experimental data. They connect the application and runoff for the 250-ft plots. The dotted lines represent an extension of the runoff flow decreased at a rate equal to the infiltration of the same

plots. The flow lines were extended until the flow was depleted. This zero point was arbitrarily selected as being most suitable for this presentation.

Fig. 6 showed, for example, that an application of 0.72 cfm per furrow was enough to irrigate 1350 ft of row crop on a 7 per cent slope, while an application of 1.02 cfm on a 2 per cent slope was enough for 1050 ft. On three-year-old alfalfa it required an application of 1.19 cfm per furrow to irrigate 825 ft on the 7 per cent slope, and 1.60 cfm for 680 ft when irrigated on a furrow grade of 2 per cent.

Looking at it another way, an application of 0.50 cfm per furrow will irrigate 950 ft of row crops on 7 per cent grade and 500 ft on 2 per cent grade. It will irrigate 415 ft of old alfalfa on 7 per cent grade and about 280 ft on a 2 per cent grade.

A 660-ft run will require 0.35 cfm per furrow for 7 per cent row crop and 0.66 cfm on the 2 per cent slope. Three-year-old alfalfa would require an application of 0.90 cfm on 7 per cent and 1.53 cfm on 2 per cent slope.

Fig. 7 shows the relationship between erosion and rate of flow for individual irrigations during the season. These show that the irrigations preceded by cultivation and ditching produced heavy soil losses while similar flow in furrows not disturbed since the last irrigation produced only a small amount of erosion. The influence of soil disturbance on erosion is clear. Note also that for some irrigations the erosion was greater on the 2 per cent furrow grade. This is attributed not to any change in the inherent transporting power of the two furrow streams but to the difference in the availability of soil in a condition susceptible to erosion.

To supplement the erosion data for the individual irrigation shown in Fig. 7, the rate of erosion for the July 6 to 9 irrigation on corn is shown in Fig. 8. It shows that erosion takes place early in the irrigation, and that on slopes of approximately 7 per cent, practically all the erosion takes place with-

TABLE 2. RELATIONSHIPS OF APPLICATION RATE AND RATE OF ADVANCE AND TERMINAL VELOCITIES ON 1946 ALFALFA

Application per furrow		Velocity, fpm		Application per furrow	Velocity, fpm	
Nominal	gpm	Initial	Terminal	gpm	Initial	Terminal
First cutting year				Third cutting year		
7 per cent furrow grade						
q	2.3	3.4	35.4	3.3	2.5	33.1
2q	4.3	9.2	38.7	6.2	10.4	38.8
3q	6.6	13.9	44.6	10.0	15.6	46.0
2 per cent furrow grade						
q	3.2	3.7	33.9	4.4	2.8	23.7
2q	6.3	10.9	40.8	8.5	8.3	28.6
3q	9.8	14.7	45.4	12.5	11.5	32.7

in 3 to 4 hr after runoff begins. One plot which had a total soil loss of 22.7 tons per acre during a 24-hr irrigation lost 17.3 tons during the first 32 min of flow. The entire 22.7 ton loss took place within 4 hr. Irrigation after the fourth hour

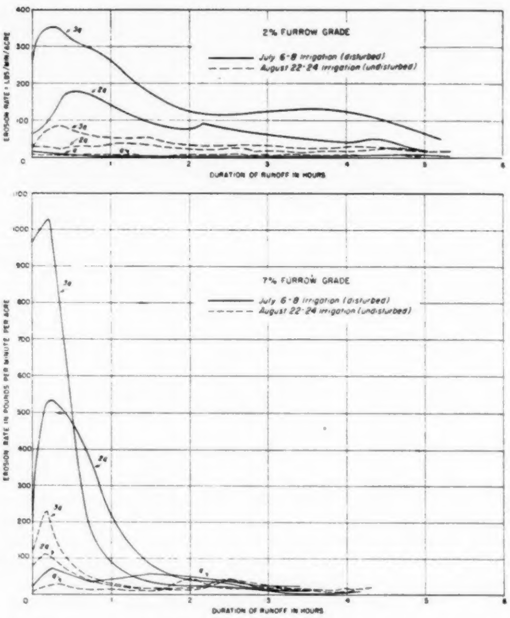


Fig. 8 Character and rate of erosion during runoff. Each curve is the average of triplicate plots

added nothing to the total erosion though the furrow flow continued at the same or greater rate.

The use of a large head at the beginning of an irrigation to get the water through and then making a final setting may be desirable for irrigating convenience. The surge of this large stream will, however, cause excessive erosion. If this large stream flows for 3 to 4 hr it will cause in that time practically all the erosion damage it will do during the entire irrigation. Letting this stream on for even two more days would add very little to the total erosion damage.

There is considerable literature on the influence of velocity on the silt-carrying capacity of streams, unfortunately there is not very much information on the velocities usually encountered in irrigating streams. Table 2 shows some velocity measurements obtained for irrigating streams flowing in furrows with a 2 per cent and 7 per cent grade.

The initial velocity is based on the time intervening between the beginning of application and the beginning of runoff. This is the velocity of the advancing stream front. The terminal velocity is based on the interval between the time the water was turned off and the time this drop in head was recorded on the runoff chart. This time interval is actually the measure of the time of concentration for this plot. By

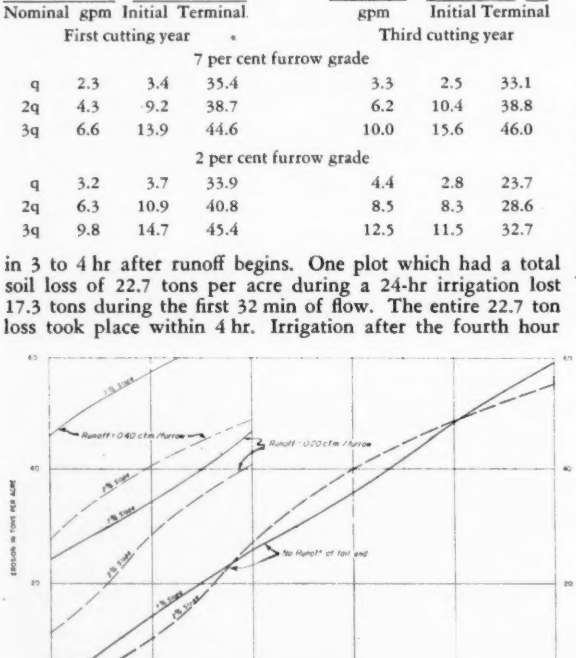


Fig. 9 Erosion along irrigation furrows as influenced by rate of runoff

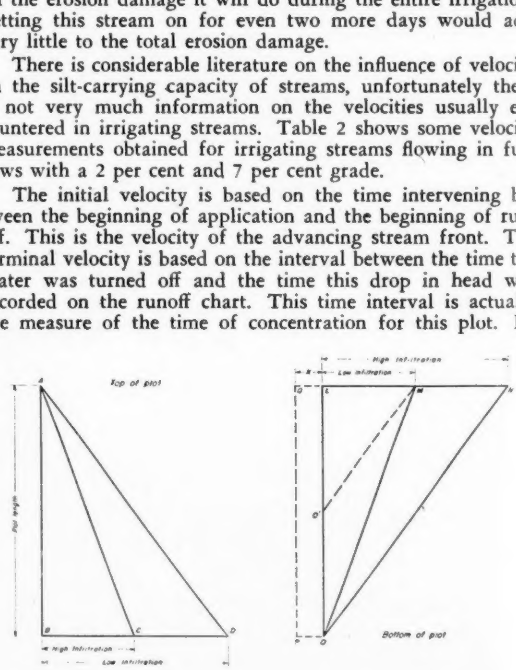


Fig. 10 Schematic representation of rates of surface flows as influenced by infiltration for rainfall and irrigation conditions

synchronizing the application and runoff recorder clocks, the time measurements were accurate to within ½ min.

The "terminal velocity" may also represent the velocity over all but the first hour or two of the irrigation. Since the runoff levels off after that time and since practically all of the erosion takes place within that time, it would seem that the hydraulic characteristics of the furrows are fairly uniform after about 2 hrs of runoff.

The one outstanding feature of this velocity data is that there is no very great difference between the velocities on the 2 per cent slope and those on the 7 per cent grade.

Comparison of Erosion Losses. To compare the erosion on one field with that on another requires the knowledge of two factors, namely, (1) how much water is flowing along the furrows of two fields in question and (2) what are the eroding and silt-carrying characteristics of those flows under the existing conditions. This means combining the data shown in Figs. 5 and 6. For row crops the net result is as shown in Fig. 9. There is very little difference between the erosion on the 2 per cent grade and that on 7 per cent grade when application rates are adjusted to just equal the infiltration rate and produce no runoff at the end.

Greater erosion on the steeper slopes and less on the flatter ones has been noted by many observers and the above conclusion seems at variance with those observations.

The following explanation is offered. In field practice the irrigator tries to set the water at each furrow so as to have a certain amount of runoff or tail water from the lower end. The irrigator strives to keep this tail water or runoff uniform on all furrows. In general, this tail water will be the same, regardless of whether the field has a 2 or 20 per cent slope, whether the infiltration is 1 in per hr or 0.10 in per hr. The erosion comparison must therefore be made for similar runoff flows, not similar per cent runoff.

Let us evaluate a 400-ft run on a 2 per cent grade and one on a 7 per cent grade at a runoff of zero, 0.20, and 0.40 cfm per furrow, respectively. We will use the flows as shown in Fig. 6 and erosion values from Fig. 5. For conditions of "no runoff" the comparison is between the erosion caused by a flow which amounts to 0.22 cfm at the top of the 7 per cent slope and 0.38 cfm at the top of the 2 per cent slope. Both the flow and erosion are reduced to zero at the bottom.

For a tail water of 0.20 cfm per furrow at the bottom of each slope, the comparison is between a furrow flow varying from 0.41 to 0.20 cfm on a 7 per cent slope and from 0.59 to 0.20 cfm on a 2 per cent slope. For a runoff of 0.40 cfm, the flow varies from 0.61 to 0.40 cfm on a 7 per cent slope and from 0.77 to 0.40 cfm on a 2 per cent slope.

Erosion rates applicable to these flows are plotted from Fig. 5. The analysis shows that (1) for field conditions with definite amounts of runoff there is greater erosion on the steeper slopes, (2) even under conditions of no runoff there will be erosion on the upper end of the run and (3) head control measures are more effective on the steeper land. It points out also the inadequacy of using per cent runoff as a basis for comparing erosion.

Increased Infiltration Increases Erosion Hazard. Perhaps most conspicuous difference between erosion under rainfall conditions and that under furrow irrigation is the influence of infiltration on surface flow. Interpretation of the results to date have led me to the disturbing conclusion that the usual good farming practices such as rotation, contouring, addition of organic matter, and other practices that increase infiltration, may actually aggravate the erosion problem by necessitating a greater furrow flow.

Increased infiltration under rainfall conditions is always accompanied by a corresponding decrease in the rate of runoff. For example, a plot with an infiltration rate of 0.1 in per hr when subjected to a precipitation of 0.3 in per hr produces runoff at the rate equal to the difference or 0.2 in per hr. When infiltration is raised from 0.1 to 0.2 in, the same precipitation causes the runoff rate to drop from 0.2 to 0.1 in per hour.

Under furrow irrigation, however, just the opposite takes place. Increasing the infiltration will require a greater irrigating head and cause a correspondingly greater flow all along the furrow. Fig. 10 is a schematic representation of the surface-flow rates. For rainfall conditions, the surface flow is high under low infiltration and is represented by the triangle ADB and that under high infiltration is low as shown by ACB. Low runoff accompanies high infiltration and the high runoff rate is the result of low infiltration.

Under furrow irrigation the low infiltration rate will require an application rate at the top of the furrow equal to that represented by the line LM and the furrow flow will decrease as shown by the triangle LMO. If this irrigating head (LM) were applied to the high-infiltration conditions, it would flow as shown by the triangle LMO'. The water would be absorbed twice as rapidly, and it would be sufficient to wet only half of the furrow length. To irrigate the entire length it becomes necessary to raise the application rate to that represented by the line LN. For this higher infiltration, the flow along the furrow is represented by the triangle LNO. It would, at all points, be twice that under the low-infiltration conditions represented by triangle LMO.

The flow represented by the rectangle LOPQ is the application in excess of infiltration. It merely adds a constant value to the flow at all points and appears as runoff at the lower end of the furrow.

The above discussion should strengthen the contention that, while infiltration tends to decrease surface flow under rainfall conditions, it increases surface flow under furrow irrigations. This should demonstrate also that the infiltration rate determines the minimum irrigating head below which it cannot be reduced without decreasing irrigation at the lower end of the run. If decreased flow reduces erosion, conversely increasing the flow will increase erosion regardless of whether the flow is increased by accident or by design. It seems therefore that under furrow irrigation practices which increase infiltration increase the erosion hazard by necessitating a greater furrow flow.

Whether the other changes that accompany changes in infiltration have an effect on the erodibility of the soil is a question not yet satisfactorily answered. If there is any decrease in the erodibility, there will still be the question of whether this improvement is enough to offset the increased erosion caused by the greater flow. Though much has been reported showing that rotations, contouring, organic matter, etc, decrease erosion, most of these tests were accompanied by a decrease in the rate of runoff. It is true that these treatments cause the soil to erode less under the same rain. It is not so clear just what the erosion would be under identical runoff conditions.

SUMMARY

The primary objective of this paper is to outline the method and thinking followed in the study of erosion under irrigation.

The procedure consisted of three steps. First is the determination of the amount of silt a number of different rates of flow will pick up and carry under different crop and furrow conditions. Second is the determination of the magnitude of flow rates occurring under the different crop and furrow conditions. Third is the combining of the first two steps. This gives definite erosion values for the entire length of the furrows.

Some definite conclusions are indicated. It is possible to have serious erosion on the upper end of irrigated fields even when neither soil nor water are wasted at the tail end. This is because the upper end of irrigating furrows carries a greater amount of water.

Any practice that increases infiltration requires an increase in the irrigating head. Increasing the infiltration decreases the percentage of runoff but increases the potential erosion hazard along the furrow.

Reditching and otherwise disturbing the soil in the furrow is one of the greatest factors in increasing erosion. Even in such crops as alfalfa and wheat, reditching tears out the vegetation and leaves the unprotected soil in contact with the flowing water. *(Continued on page 389)*

Drainage Investigations in the Plastic Till Soils of Northeastern Illinois

By E. H. Kidder and W. F. Lytle
MEMBER A.S.A.E. MEMBER A.S.A.E.

IT HAS long been recognized that soils in northeastern Illinois which developed from plastic glacial till were difficult to drain properly. Normal tile depths and spacings have not given satisfactory drainage in ponded areas. The study reported in this paper covers exploratory work in the effectiveness of tile drainage. It is in no sense a completed investigation. Some facts are presented to show the effectiveness of tile systems.

Soils. Many of the soils in northeastern Illinois were formed from a thin blanket of loess resting on various kinds of glacial till. This study is concerned with those soils underlain with extremely fine-textured or heavy glacial till through which gravitational water drains very slowly. The three soil groups involved are the Elliott-Ashkum, Swygert-Bryce, and Clarence-Rowe-Monee. These soils are grouped in order of decreasing permeability. The Rowe, Monee, Bryce, and Ashkum soils occupy the nearly level to depressional areas and usually present more of a drainage problem than the gently sloping Clarence, Swygert, and Elliott soils.

Equipment and Operation. A series of wells were installed at variable intervals of 2 to 20 ft on a line perpendicular to the tile line. The wells were constructed by boring a vertical hole into the soil to the depth of the bottom of the tile. The holes were curbed with a perforated metal or plastic pipe whose unperforated top extended several inches above the soil surface. These casings were varied in size from ¾ to 2 in. The size of the casing was kept constant on individual sites. Profile elevations on the ground and the top of each well were made. The top of each well was covered with a metal plate. Readings were made with an electric probe. A milliammeter on the probe was deflected when the contact end of the probe touched the water surface. The probe was graduated in hundredths of a foot. A standard non-recording rain gage was installed on each farm to measure the precipitation prior to and during the period of measurement. Following a period of precipitation daily readings were made on the level of the water surface in each well. The data on the rate of drop of the water surface in the A and B horizons was adjusted to 24-hr intervals. Water-level measurements were made on the Monee silt loam in April, 1947, and on the other soils during March, April, and May, 1948.

This paper was presented at the winter meeting of the American Society of Agricultural Engineers at Chicago, Ill., December, 1948, as a contribution of the Soil and Water Division. The study reported in this paper is being conducted as a cooperative project of the Illinois Agricultural Experiment Station and the Soil Conservation Service (Research), U. S. Department of Agriculture.

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TABLE 1. DESIGN AND PERFORMANCE OF TILE DRAINAGE SYSTEMS

Soil type	Elliott silt loam (Site 1)	Bryce silty clay loam (Site 2)	Bryce silty clay loam (Site 3)	Clarence silt loam (Site 4)	Rowe silty clay (Site 5)	Monee silt loam (Site 6)
Age of system, years	0.5	± 20	0.5	36	± 20	36
Tile size, in	4	6	6	6	6	4
Tile depth, in	35	33	33	32	41	30
Tile grade, ft per 100 ft	0.4	0.3	0.38	1.13	0.01	-
Tile location, soil horizon	*C*	*B*$_2$-*C*	*B*-*C*	*B*	*C*	*B*
Present crop	Clover plowed	Alfalfa	Timothy pasture	Alfalfa	Timothy pasture	Clover plowed
Crop rotation *	C, O, Cl	C, S, C, O, Alf	Unknown	C, S, O, Alf	C, S, C, O, Pas. 2 yr.	Unknown
Extent of good drainage, feet	20	5-10	2	10-15§	0	5
Natural rate of water recession, ft in 24 hr †						
A horizon	0.63	0.22	0.12	0.48	0.23	0.44 - 0.59
B horizon ‡	0.25	——	——	0.23	——	0.11

* C — corn, O — oats, Cl — clover, S — soybeans, Alf — alfalfa, Pas. — pasture.

† Rate of drawdown in *A* and *B* horizons in areas beyond influence of the tile system.

‡ The combination of frequency of storms and slow rate of water movement prevented satisfactory measurement of drawdown in the *B* horizon.

§ Occasional sand lenses encountered. Drainage is probably more rapid than normally found in Clarence silt loam.

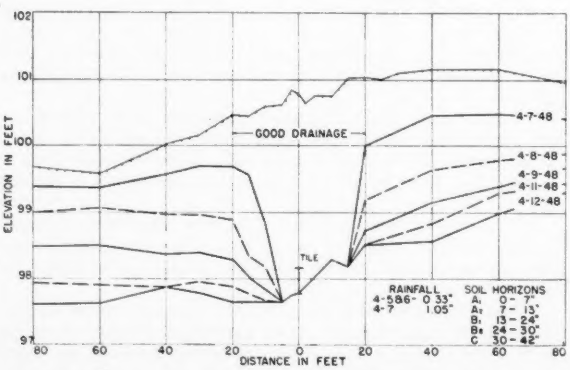

Fig. 1 Drawdown curves for Elliott silt loam (Site 1)

RESULTS AND DISCUSSION

The data collected during this study are presented in Table 1 and Figs. 1 to 6. We have used the criteria that good drainage is obtained when the free water is removed to a depth of 12 in in the first 24 hr and to a depth of 21 in within 48 hr. Neal[3] observed that crops were not seriously injured if the water table was held at least 6 in below the surface and was lowered at the rate of one foot per day through the second 6-in-depth interval and at the rate of 0.7 ft per day through the third 6-in-depth interval.

The shape of the drawdown curve between two tile lines is usually considered to be semielliptical. Only in soils of uniform permeability can one expect to find this idealized form. Under field conditions in most soils this curvature will be distorted as the permeability of each soil horizon varies through the profile above the tile.

We believe that their well measurements indicate the

* Superscript numbers refer to appended references.

level of the top of the retreating water surface in the soil. This is not the surface of the permanent water table but instead is the top surface of a new mass of water that is moving downward through the profile to the water table.

Two tile lines were found on the Bryce silty clay loam site 2. The second line was located during the process of installing the wells to measure the effectiveness of the test line. The second line was located at a depth of 22 in. This depth establishes the location of the tile as being in the B horizon. Its presence did affect the position of the water level on successive days, but, because of its shallowness, its effectiveness (Fig. 2) in the interval between the two lines was not appreciable after the third day.

The Bryce silty clay loams, sites 2 and 3, are good examples of the variation that exists within a soil type. Site 2 was found to be more permeable and more friable than typical Bryce. Site 3 was heavier and less permeable than average. It is probable that the variations in soil had a direct bearing on the extent of good drainage that was measured on these sites (Table 1, Figs. 2 and 3).

Sand lenses are not common in Clarence silt loam. The rapid downward movement of the water surface from the tile to a point 15 ft northwest of the tile indicated the presence of a highly permeable layer on site 4. The extent of good drainage was measured in an area considered to be beyond the influence of the sand lens (Fig. 4).

Supplementary soil permeability measurements were made in the A, B, and C horizons of some of these plastic till soils in the early summer of 1948. Four-inch auger holes were bored into but not through each horizon. A half-inch head of water was maintained on the bottom of each hole for a 4-hr period on two successive days. The amount of water taken into the soil by one-hour increments was determined from readings of the cubic centimeters of water withdrawn from the burettes. The data from the wet run (second day) are included in Table 2.

TABLE 2. FIELD PERMEABILITY RATES FROM WET RUNS ON PLASTIC TILL SOILS

	Water intake in inches per hour				
Soil type	Elliott silt loam*	Bryce silty clay loam (Site 2)	Bryce silty clay loam (Site 3)	Clarence silt loam (Site 4)	Rowe silty clay (Site 5)
Soil horizon					
A_1	0.34	1.18	0.007	0.03	0.17
A_2	3.57	0.91	0.75	0.47	0.11
B	3.60	0.74	0.35	0.54	0.06
C	0.49	0.58	0.37	0.54	0.10

* Permeability measurements were made on a site whose soil is similar to site 1.

The permeability rate of the A_1 horizon of the Elliott silt loam is 0.34 in per hr (Table 2) as compared to a permeability of 3.57 in per hr in the A_2 horizon. It is possible that past rotations and management have caused a reduction in the permeability of the A_1 horizon.

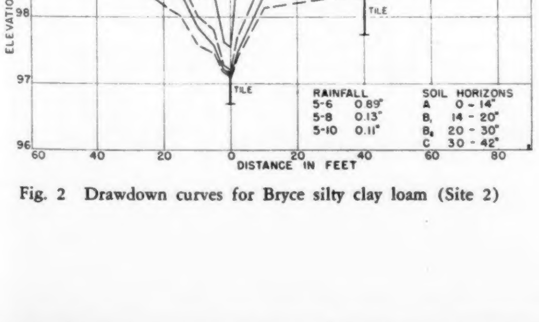

Fig. 2 Drawdown curves for Bryce silty clay loam (Site 2)

Research workers[4] have contended that from the standpoint of soil structure or physical properties a rotation including the combination of a deep-rooted legume and a grass is most ideal. The grass seems to have a structure-building effect in the surface soil and deep rooted legumes have the effect of loosening and adding organic matter to the deeper soil horizons. It is therefore possible that a rotation including alfalfa-brome might improve the permeability of the A_1 horizon of the Elliott silt loam. Likewise, this grass-legume rotation may provide beneficial effects to the A_1 horizons of the site 3 Bryce silty clay loam and the Clarence silt loam. Legume roots do not readily penetrate the soil mass of the B and C horizons but tend to follow vertical fractures, cleavages, and cracks. Observations indicate a very limited amount of horizontal rooting in these layers. The immediate effect of the deep-rooting legumes seems to increase the profile storage capacity of the soil.

Baver[1] states: "The primary influence of adequate drainage on soil structure lies in the removal of excess water, with a corresponding increase in the air capacity. This increase in aeration is accompanied by greater root development, more intense bacterial activity, and the promotion of oxidation processes. The combined effects of these factors lead to better granulation." The improvement in granulation of the well-drained soil adjacent to the tile should provide a more permeable outlet for free water from the adjoining less well drained soil mass.

Because of the recent date of installation of the tile systems in the Elliott silt loam (Site 1) and the Bryce silty clay loam (Site 3), a very slow improvement in the extent of good drainage can be expected if a rotation is followed which includes a good grass-legume mixture. The ideal time to tile a field would be in the year preceding the seeding of a grain nurse crop with a grass-legume mixture.

The drainage engineer needs information on the texture, pore size, and permeability of the *A*, *B*, and *C* horizons. Where a recent soil conservation survey or soil survey map is available in his area of operation, he should become thoroughly familiar with it. He should learn the profile characteristics of each soil unit so that he will be in a position to recommend depths and spacings of tile that are correct for the particular soil. He must be aware of the variation that does occur within a soil type; for example, in the two Bryce silty clay loam sites that were used in this study, the Bryce on site 2 had a much higher permeability rate through all horizons than the Bryce on site 3. It does not appear reasonable to recommend the same tile depth and spacing for each site even though they bear the same type name.

The engineer should have some kind of soil physical test by which he can determine how each horizon in a profile is going to drain. The existence of a tight horizon either above or at the depth of the tile will greatly affect the operation of the system even though the surface layer may be highly permeable. Leamer and Shaw[2] have suggested a practical technique which should give the minimum amount of air

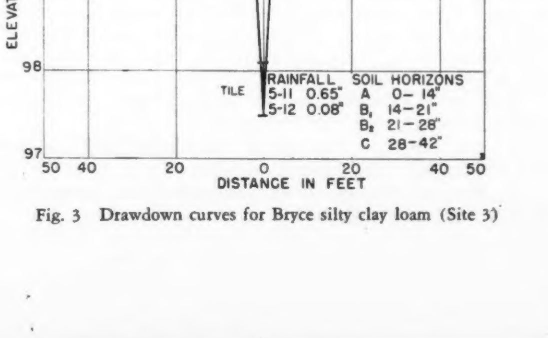

Fig. 3 Drawdown curves for Bryce silty clay loam (Site 3)

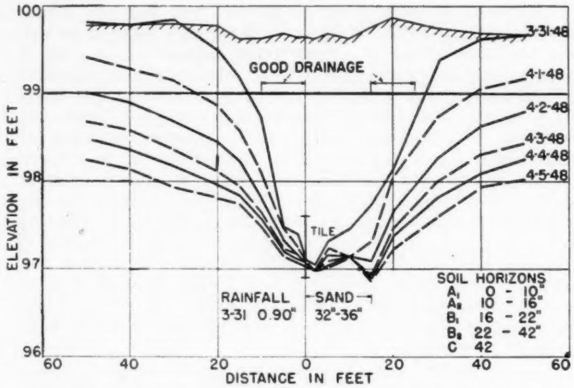

Fig. 4 Drawdown curves for Clarence silt loam (Site 4)

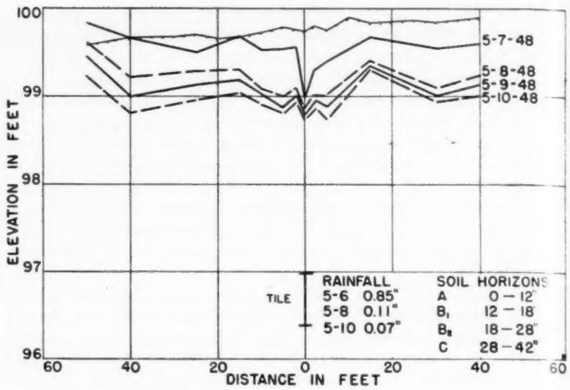

Fig. 5 Drawdown curves for Rowe silty clay (Site 5)

space in a drained soil. Since it is an important factor in tile drainage, some preliminary tests were made to determine the cubic centimeters of pore space with 60 cm of tension. Three-inch diameter undisturbed core samples 3 in in depth were removed from the field and saturated. Percolation was measured for a period of one hour with a head of 0.5 in of water maintained on the top of each core. Following the percolation test, the cores were removed to a tension table. The cores were reweighed after having been subjected to 60 cm of tension for one hour to determine the cubic centimeters of pores drained. Any soil which has a horizon at or above the level of the tile whose pores drain less than 12 cc probably will not drain satisfactorily (Table 3). The Clarence, Rowe, and Bryce soils fall in this group. Considerable development work needs to be done before the test can be applied to classify soil drainability.

TABLE 3. CUBIC CENTIMETERS OF PORES DRAINED IN ONE HOUR AT 60 CM TENSION

Depth*	Cubic centimeters pores drained				
	Elliott silt loam (Site 1)	Bryce silty clay loam (Site 2)	Bryce silty clay loam† (Site 3)	Clarence silt loam (Site 4)	Rowe silty clay (Site 5)
Soil horizon					
A_1	16	20	....	9	1
A_2	23	25	....	9	3
B	24	16	....	10	4
C	6	12	....	12	3

* Top of sample, inches depth from surface: A_1, 2 in; A_2, 10 in; B, 15 in; C, 30 in.

† Impossible to get pores drained as surface of soil in cores failed to become saturated on soaking.

Those soils which occur on the flatter slopes and depressional areas such as the Bryce silty clay, Rowe silty clay, and Monee silt loam, will not drain satisfactorily by lateral tiling where there has been an appreciable volume of runoff ponded on the surface. Tile systems equipped with surface inlets or drainage channels are needed to remove ponded water rapidly. The open type of surface inlet is most desirable, but precautions must be taken to screen out debris and to provide silting basins to remove heavy sediments. Satisfactory trapezoidal and V-shaped channels have been constructed on grades as low as 0.5 ft per 1000 ft. These channels are shaped so that they can be readily crossed at any point with power machinery. Filter elements or blind inlets constructed of tile batts, sand and gravel, and corn cobs have been tested in a depressional area with a soil similar to Bryce silty clay loam and found to be unsatisfactory after two years of operation.

The results from this study to date emphasize the need for further investigation of the following:

1 The effect on drainage of using good crop rotations that include grass and legume mixtures.

2 The probable use of field and laboratory permeability data in tile system design.

3 The development of a reliable technique and possible use in designing tile systems. (The non-capillary pore space as determined by a drainage tension offers promise.)

4 The influence of the rate of drainage on crop yields.

5 The minimum rate of removal of gravitational water to prevent crop damage at successive stages of growth.

6 The peak rates and volume of flow from tile systems to determine the actual drainage coefficient for a given depth and spacing.

7 The design of surface inlets to remove a maximum amount of sediments without interference with rapid removal of runoff.

SUMMARY

A study was made on the drainability of the plastic till soils of northeastern Illinois.

Perforated pipe wells were installed at intervals on a line perpendicular to a tile line. Daily measurements were made on the level of the water surface in these wells following periods of rainfall.

For the purposes of this discussion, the criteria of good drainage is the removal of the free water from the surface 12 in within 24 hr and from the surface 21 in in 48 hr. The following benefits from tile drainage were determined:

Soil type	Lateral extent of good drainage, ft
Elliott silt loam	20
Bryce silty clay loam (site 2)	5 to 10
Bryce silty clay loam (site 3)	2
Clarence silt loam	10 to 15*(1)
Rowe silty clay	0
Monee silt loam	5

* Drainage may be more rapid on this site than on typical Clarence.

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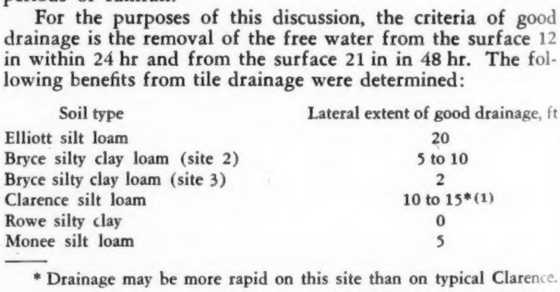

Fig. 6 Drawdown curves for Monee silt loam (Site 6)

Water and Irrigation Needs of the Pacific Coast

By Irvin H. Althouse
FELLOW A.S.A.E.

THIS subject applies to a considerable area in which are found great extremes of irrigation requirements, and also great extremes of precipitation.

It was only about eight months ago that the Columbia River went on a rampage, delivering about 2,000,000 acre-feet of water per day at its peak flow into the Pacific Ocean. Probably from May 15 to June 15, inclusive, about 49,000,000 acre-feet of water were discharged into the sea. This is equal to about two-thirds of the normal annual water crop of California. This great extreme compared to the droughts of the deserts, which are made to blossom as the rose with irrigation, is about as contrasting as can be found anywhere in the world.

According to Genesis 2:10, irrigation was practiced in Bible lands: "And a river went out of Eden to water the garden; and from thence it was parted, and became into four heads." A noted English engineer claims to have found traces of the canals which were used to divide the water. It has not been too many centuries ago that the California padres made use of water. This was started in the lush lowlands where cattle were grazed and fed as in the historic past. However, with man's ingenuity plus the prompting of desire for greater gains, ditches were devised to distribute the water over larger areas so that more grasses could be grown for more cattle and more farming. This practice was continued to the present age. When this method did not suffice, wells were dug and water removed by pumps and forced to higher lands. It was also found that water could be secured under lands that were far removed from the river bottoms. Thus agriculture by the use of irrigation practices started, resulting in millions of tons of food and fiber being produced for man in every part of the globe.

In California areas it was soon found that the cost of developing water was becoming more expensive. The low-cost water areas were naturally the first to be used and acquired. The costs of water development increased with each new method used to deliver it to areas which were more distant from the natural source or stream.

In order to economize, groups of neighbors joined and cooperatively dug wells. These pumping groups called themselves mutual companies or organizations. They could do collectively what they could not do individually, and do it more economically. However, with the great progress of irrigation practices in farming, even these mutual water companies in certain areas soon found that their problems were getting greater than they could care for. As early as 1887, and prior to the era of extensive well development, large projects were contemplated, and in California irrigation district laws were passed, providing ways and means for financing and constructing larger projects that could not be accomplished by individuals or smaller groups.

In all of these various types and methods of irrigation practice, the landowner had full control, or control of his water to some degree. It is to be noted that the larger the group became, the less individual control was possible. Controls in the irrigation district, being a political subdivision or state agency, are effected through the voting power of the electors in the district and property owners are represented by directors.

Even with the formation of large irrigation districts, some of which are over 500,000 acres in size, such as the Imperial Irrigation District in California, there are projects in the making and under construction which are too large for such organizations, and, at one time at least, it was felt that the Central Valley Project was even too large for California; hence, the taking over of the construction work of this immense project by the federal government. In the light of even a project of the magnitude of the Central Valley Project, water is still the keynote and most important commodity requirement when considered in the light of future development of California. This is well recognized by the shortages of water occurring in the large metropolitan cities and their suburban areas. In some localities on the coastal plains, intrusion of saline water has occurred to a point where it is a serious matter. Water is already being transported hundreds of miles for both of the largest centers of population in the West.

The saline problem has not only appeared along the southern coastal plains. In the south central portion of the San Joaquin Valley, many acres of well-improved lands would have been lost years ago had it not been for an imported temporary supplemental supply that was developed, resulting in extensive litigation.

Here it appears that wells have penetrated soils, which, in past geological ages, were under the sea. The temporary supply will be superseded by water from the Central Valley Project now under construction.

Saline intrusions have also threatened the rich delta lands of the lower Sacramento and San Joaquin Valleys. Reduced runoff of the Sacramento and San Joaquin Rivers during drought years, and more particularly increased and heavy diversions from these rivers, permitted the saline waters of the San Francisco, San Pablo, and Suisuin Bays to reach inland and replace fresh river waters.

Vast increases in the population of the Pacific Coast states in recent years can but add to the water requirements of the respective states to which they come. To maintain their livelihood, both industry and agriculture must find more jobs. This cannot be done without more water.

Many areas at this time are already oversaturated, when measured in terms of ability to sustain the large population, because of insufficient water supply. There are likewise other places in the nation that have insufficient water supplies.

At the beginning of the paper the wide extremes of precipitation and water supply was indicated. That is true in California where the majority of the water is precipitated in the northern part of the state and the major part of its use required in the southern part of the state. The water production, irrigable areas, and their requirements in various sections in California are indicated in Table 1, the data having been secured mainly from Bulletin 4, Department of Public Works, State of California, "Water Resources of California."

TABLE 1. ANNUAL RUN-OFF, IRRIGABLE ACRES, AND WATER REQUIREMENTS OF CALIFORNIA BASINS, IN THOUSANDS OF ACRE-FEET

	Mean annual runoff, acre-feet	Irrigable acres	Annual duty, acre-feet per acre	Irrigation requirements, acre-feet
North Pacific Basin	26,835	624	1.25	781
Sacramento Basin*	25,200	5,452	2.25	12,270
San Francisco Bay Basin	825	826	1.6	1,322
San Joaquin Basin*	12,331	8,239	2.25	18,530
South Pacific Basins	3,442†	1,804	2.20	3,970
Great Basin and Northeast Plateau	3,898‡	4,661	2.25	10,500
Totals§	72,531	21,606	2.19	47,373

* No consideration for effect of C.V.P.
† Not including 1,212,000 acre-feet from Colorado River
‡ Not including 4,150,000 acre-feet from Colorado River
§ Not including 5,362,000 acre-feet from Colorado River

NOTE: References to water from Colorado River are to California entitlements under the Colorado River Compact.

This paper was presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers at Davis, Calif., February, 1949.

IRVIN H. ALTHOUSE is a consulting engineer, Porterville, Calif.

California's approximately 21,600,000 acres of irrigable lands require about 47,000,000 acre-feet of water which is, in contrast, about 23 per cent of the normal annual flow of the Columbia River. The total estimated water production in California is about 72,500,000 acre-feet, of which at the present time probably not more than 40 per cent could be expected in a firm supply if developed through storage. Even then it would involve great transportation problems.

In order to secure the maximum possible yield of 58,000,000 acre-feet, which is about 80 per cent of the state's normal annual water crop, it would require an over-all storage development of about 185,000,000 acre-feet to equalize the stream flow. This is more than two and one-half times the average annual water crop of California. The ratio of stored water to net yield of equalized flow is 3.17:1. Under present conditions, such a storage development project is far from present reasonable economic standards and would probably not be justified. On the 40 per cent basis, and to secure a yield of 29,013,000 acre-feet per season, the total storage required to equalize stream flow would be about 31,400,000 acre-feet. This amounts to a storage of 1.08 acre-feet for each acre-foot of water net yield. On the basis of a net yield of 50 per cent of the average annual flow, a gross storage of about 48,000,000 acre-feet would be required, the ratio of storage capacity to net yield being 1.32 to 1.00. These problems have received the attention of the U. S. Bureau of Reclamation and U. S. Corps of Engineers, who point out the long time that would be required to complete such development.

Moreover, it must be borne in mind that the figures as quoted indicate the entire water yield and requirement as being in a single pool. The problem is not as simple as that. The areas of greatest water yield are farthest removed from areas of greatest need. While seemingly there is no problem that cannot be solved by engineering and construction, there must be both the means and justification and either or both may be limiting or governing factors.

To illustrate, Tables 2 and 3 indicate the average seasonal runoff of the respective basins, the storage capacity required to equalize stream flow for the maximum net yields of 80 per cent of the average runoff, and the net yield of about 50 per cent.

The foregoing statements have dealt solely with the irrigation requirements. What about the priority supply for domestic water and that needed for industry? California is heading for a population of 15,000,000 by 1960, and 20,000,000 by 1980 or sooner. Allowing 100 gal per capita per day, the additional requirement for domestic water would be about 1,800,000 acre-feet annually. Industry, it is estimated, will require by that time about 4,000,000 acre-feet. These uses would be concentrated in the metropolitan areas and larger centers of population. Because of this situation, the already deficient areas of San Francisco Bay and South Pacific would be the more pressed for water by about 2,000,000 acre-feet and 3,800,000 acre-feet, respectively.

In comparison to California's water resources and requirements, let us take a look at the state of Washington, the irrigable acres of which are, for the most part, located in the Columbia River storage basin and comprise a little over 8,000,000 acres. These will probably require some 16,000,000 acre-feet of water on a consumptive use basis. Available water is the Columbia River with an annual water crop of 195,000,000 acre-feet, of which about 170,000,000 acre-feet originate, pass through, or are available to that state, in addition to an estimated 20,000,000 acre-feet coming from the western slope of the Cascade Range. There are several projects, including the Grand Coulee in Washington, being constructed by the federal government, which will care for a very large part of this area. The particular problem in Washington, therefore, appears to be to harness and use the water not only for agricultural use, but for power generation, industry, and for protection against damages by floods.

In Oregon, it is estimated that there are 1,200,000 acres presently irrigated and an additional 1,400,000 acres irrigable, a total of 2,600,000 acres irrigable, and requiring about 5,000,000 acre-feet of water. The mean annual water yield in Oregon is estimated at 50,000,000 acre-feet, or about ten times the estimated irrigation requirements.

From personal knowledge, I can say that there are areas in eastern Oregon in need of additional water and that the water is not evenly distributed. Future development of these lands will substantiate this, as well as the historical fact, as established in other areas, that the lands developed easily and at low cost will come first, the more costly later, as economics and requirements dictate and justify.

More detailed data from Oregon and Washington was not available in the short time allotted for the preparation of this paper. From the response to inquiries, however, it seems that figures on irrigation are not as readily available as in California. It is reasonable to suppose that, because of the large amounts of water present from precipitation and stream flow, the necessity for such data is not deemed so urgent.

In the more arid areas where the water supply is scarce and must be put to the greatest beneficial use, much interest in developing new projects is shown in the matter of ascertaining the irrigation water supply and requirements for crops. Various methods have been pursued, technical and practical to find solutions that can be readily applied to respective areas. While it is not the purpose here to discuss the merits and details of the many formulas devised, a few

TABLE 2. Average Annual Runoff, Irrigation Requirements, Surplus and Deficiencies Based on Maximum Yield from Equalized Stream Flow in California Stream Basins, in Thousands of Acre-Feet

Basin	Average annual runoff	Annual requirement	Maximum yield	Storage required for equalized flow	Ratio — storage to net yield	Surplus	Deficiency
North Pacific	26,835	781	22,625	72,024	3.18	21,844	
Sacramento	25,200	12,270	20,264	56,381	2.78	7,994	
San Francisco	825	1,322	595	2,851	4.79		727
San Joaquin	12,331	18,530	9,573	26,156	2.73		8,957
South Pacific*	4,654	3,970	3,494	16,595	7.27		476
Great†	8,048	10,500	7,071	10,901	3.73		3,429
Total‡	77,893	47,373	63,622	184,908	3.17	16,249	

* Includes 1,212,000 acre-feet from Colorado River
† Includes 4,150,000 acre-feet from Colorado River
‡ Includes 5,362,000 acre-feet from Colorado River

TABLE 3. Average Annual Runoff, Irrigation Requirements, Surplus and Deficiencies Based on Yield of 50 Per Cent of Average Runoff From Equalized Stream Flow in California Stream Basins, in Thousands of Acre-Feet

Basin	Average annual runoff	Annual requirement	Fifty per cent yield	Storage required for equalized flow	Ratio — storage to net yield	Surplus	Deficiency
North Pacific	26,835	781	13,418	15,032	1.12	12,637	
Sacramento	25,200	12,270	12,600	14,033	1.11	330	
San Francisco	825	1,322	413	976	2.37		909
San Joaquin	12,331	18,530	6,165	6,732	1.09		12,365
South Pacific*	4,654	3,970	2,927	7,267	4.24		1,043
Great†	8,048	10,500	6,087	3,833	1.98		4,413
Total‡	77,893	47,373	41,610	47,873	1.32		5,763

* Includes 1,212,000 acre-feet from Colorado River
† Includes 4,150,000 acre-feet from Colorado River
‡ Includes 5,362,000 acre-feet from Colorado River

of them will be mentioned. An interesting paper appeared in Proceedings of the American Society of Civil Engineers in April, 1941, by Lowry and Johnson, which related heat units to water requirements, the heat units representing day-degrees over 32 F. In other words, daily maximum temperature, minus 32 F, represented the heat units of that particular day. At first glance, it would seem that such a simple formula could not possibly take into account all of the factors, which are prevalent in the use of water by various crops in the many localities, such as temperature, wind, humidity, season of the year, and other factors. Before setting it aside, however, the data on the number of heat units in the Tulare County (Calif.) area were computed, and an application of the schedule made as indicated. After considering the growing season for various crops, it was a pleasant surprise to find how close the water requirements could be secured from this analysis.

Blaney and Criddle of the Soil Conservation Service, USDA, reported on "A Method of Estimating Water Requirements in Irrigated Areas from Climatological Data." Their work was along similar lines but went into greater detail by including other factors such as daylight hours. The formula worked out by them is not too involved, but it is not as simple as the Lowry-Johnson method. However, it is more reliable for any specific area. Further, Blaney and Criddle, according to this report, and as far as their investigations went at that time, had not considered other factors which would have a definite bearing on the subject.

The following are the estimated consumptive use requirements for growing crops by months for Tulare County areas in acre-feet:

January	0.05	May	0.29	September	0.42
February	0.10	June	0.45	October	0.26
March	0.14	July	0.63	November	0.15
April	0.19	August	0.59	December	0.07

The above indicates a total requirement for a 12-month growing period of 3.34 acre-feet.

Differences of crops, location, climate, soils, and irrigation efficiencies result in considerable variations as to the amount of water used and must be considered in the use of any formula.

The San Joaquin Valley and other portions of California are veritable garden spots and food baskets for the nation and the world. The bottom of the barrels have been scraped to find cheap water or water that can be obtained on a sound economic basis. Still more is required if all irrigable lands are to produce to the maximum. Dreamy and visionary eyes and minds have looked far for other sources and are even considering Columbia River water for importation into California. "Where there is no vision, the people perish," and history may repeat itself in that in a good many areas these agricultural developments may be vacated unless additional water is found. It behooves every state and community to know its water problems of supply and demand and to plan for the greatest use for the fullest future development.

The economics of water supply from such distant sources as the Columbia River could not be justified or warranted if the costs were to be borne by those using such water for agricultural and domestic purposes. It would appear, therefore, that one of two things, or both, might happen, that is, that people will go to where the water is, or if these food baskets in the great producing areas of California are a necessity and their worth to the nation is justified, would it be, or could it be that the federal government would undertake such a project? This would be no less than a subsidy in order to produce the necessary food for its own population and those of other nations.

It is not the intent of this paper to propose such immense projects nor to inject principles or policies that might have been conceived or would be worked out for the future. These matters are now subjects of great controversy and must be considered some time when the projects take more definite form and the need and justification are established.

Drainage in Plastic Till Soils

(Continued from page 386)

Field permeability studies emphasize the need of investigating the permeability of each soil horizon at or above the location of tile since the least permeable horizon will limit the inflow to the tile system.

These permeability studies indicate that considerable variation may exist in the permeability rates between fields in the same soil type. Satisfactory surface drainage channels have been constructed on minimum grades of 0.5 ft per 1000 ft.

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Erosion Under Irrigation

(Continued from page 383)

Reducing the grade by directing irrigating furrows across the slope increases both the rate of infiltration and the necessary irrigating head. It reduces the amount of erosion only under irrigating conditions where there is an appreciable rate of runoff.

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Rice Hulls for Seeding

THE lowly rice hull, long considered a waste product of little commercial value, appears headed for a modest share of fame. It apparently holds the answer to one of the farmers' oldest and most vexing problems — how to sow mixtures of different kinds of seeds in a single operation and get uniform distribution of all seeds regardless of variation in size, shape, or weight.

Discovery of the unique virtues of rice hulls was made by the Soil Conservation Service nursery at Pleasanton, Calif. It resulted from the problem of seeding mixtures of many of the new conservation forage grasses developed by the nursery.

More out of desperation than hope, the adding of liberal quantities of rice hulls to various seed mixtures was tried out. The results were startling. Each hull acted as a tiny cup which held small clusters of the different seeds in the mixture. Those not trapped in the cups, seemed to "float" in the small spaces between the hulls as if held by millions of invisible little hands. Fed through a grain drill, set for seeding barley at the rate of 160 lb per acre, the seeds and rice hulls came through in almost precise proportion to the rates of mixture. It made no difference whether the seeds were large or small, heavy or light, they were all distributed uniformly by the rice hulls.

Hopeful but not wholly convinced, the experimenter resorted to a mechanical seed cleaner and separator. No amount of cleaning could separate more than 50 per cent of the seeds from their possessive hulls.—*From "Soil Conservation", July, 1949.*

NEWS SECTION

Life Membership Conferred on Members

J. W. CARPENTER, Jr., E. B. Doran, G. B. Gunlogson, O. W. Israelsen, Geo. W. Kable, R. W. Trullinger, Hall B. White, and F. A. Wirt were recently elected life members of the American Society of Agricultural Engineers by the Council of the Society.

In taking this action the Council recognized that these men became eligible for life membership during the past year, under the provisions of Art. B 5, par. 13, of the Society's By-Laws, which specifies that members who have paid dues for 35 years, or who have reached the age of 70 years after having paid dues for 30 years, are eligible for life membership, which shall be conferred on them by the Council.

John W. Carpenter, Jr., is now a planter located at Tallulah, La.

E. B. Doran is head of the agricultural engineering department, Louisiana State University.

G. B. Gunlogson is president of the Western Advertising Agency, Racine, Wis.

Dr. O. W. Israelsen is professor of agricultural engineering, Utah State Agricultural College.

Geo. W. Kable, a past-president of ASAE, is editor of "Electricity on the Farm" magazine.

Dr. R. W. Trullinger, a past-president of ASAE, is chief, Office of Experiment Stations, U. S. Department of Agriculture.

Hall B. White, formerly a member of the agricultural engineering staff, University of Minnesota, is now in business as an architect and agricultural engineer at Northfield, Minn.

Fred A. Wirt, a past-president of ASAE, is advertising manager, J. I. Case Company.

Nominations for ASAE Medal Awards

IN ACCORD with the rules governing the award of the John Deere and Cyrus Hall McCormick Gold Medals, the Jury of Awards of the American Society of Agricultural Engineers will receive from members of the Society, up to November 1, nominations of candidates for the 1950 awards of these two medals.

Members of the Society nominating candidates for either award are requested to keep in mind the purposes of each medal and make their nominations accordingly. The John Deere Medal is awarded for "distinguished achievement in the application of science and art to the soil," which citation is interpreted to cover more than a mechanistic concept of engineering, and to include chemistry, physics, biology, and any other science and art involving the soil, the "application" being acceptable to "evaluation by the engineering criteria of practicality and economic advantage."

The Cyrus Hall McCormick Medal is awarded "for exceptional and meritorious engineering achievement in agriculture." Selections for the award may be in recognition of a single item of engineering achievement, but is more likely to be on the basis of the aggregate of weighted accomplishment through a continuing career.

The Jury of Awards desires that members of the Society consider it their duty and obligation to give serious thought to the matter and nominate for either or each of these awards the men they believe to be most worthy of the honor. Each nomination must be accompanied by a statement of the reasons for nominating a candidate and qualifications of the nominee, including his training, experience, contributions to the field of agriculture, a bibliography of his published writings, and any further information which might be useful to the Jury in its deliberations.

The Jury will accept and consider nominations received on or before November 1, and these nominations should be addressed directly to the Secretary of the Society at St. Joseph, Michigan. The Secretary will supply on request a standard set of instructions for preparing information in support of nominees for the Society's gold medal awards; in fact, it is important that these instructions be followed in preparing material on behalf of any nominee.

A.S.A.E. Meetings Calendar

August 19-21 — GEORGIA SECTION, Camp Wahsega, Ga.

September 7 to 9 — NORTH ATLANTIC SECTION, Pennsylvania State College, State College

October 6 to 8 — PACIFIC NORTHWEST SECTION, Harrison Hot Springs Hotel, Harrison Hot Springs, B. C.

October 29 — IOWA-ILLINOIS SECTION, LeClaire Hotel, Moline, Ill.

December 19 to 21 — WINTER MEETING, Stevens Hotel, Chicago, Ill.

February 9-11 — SOUTHEAST SECTION, Beuna Vista Hotel, Biloxi, Miss.

June 19-21 — ANNUAL MEETING, Statler Hotel, Washington, D. C.

Three ASAE Men on UNSCCUR Program

THE United Nations Scientific Conference on the Conservation and Utilization of Resources (UNSCCUR) will open a three-week session at Lake Success on August 17. More than 500 scientific papers will be discussed at 60 section meetings of the conference where specialists from all over the world will exchange technical experience on specific subjects concerning conservation and use of mineral, fuel and energy, land, water, forest and wildlife, and marine resources. Outstanding scientists, experts, and technicians from more than 70 countries have been invited to attend this first scientific conference to be held by the United Nations (Continued on page 392)

(Left) ASAE retiring president, A. J. Schwantes (right), congratulating representatives of the Clemson (S.C.) Student Branch of ASAE, winner of the 1949 Farm Equipment Institute trophy, during the Society's annual meeting in June at Michigan State College • **(Right)** ASAE incoming president, Frank J. Zink (left), congratulating R. C. Evans (Ohio, second from right), newly elected president of the National Council of ASAE Student Branches. Newly elected first vice-president of the Council, Joseph Pryor (Georgia) is at the extreme right. Newly elected secretary of the Council, Edgar E. Gammon (Maine), is third from right

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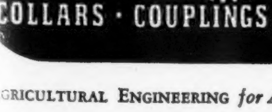
wins "O.K." for Algoma's new O-K forage blower . . . .

Ten-foot flight of Link-Belt Helicoid screw conveyor feeds chopped hay and fodder into the blower. Link-Belt screw conveyors, Helicoid or sectional, can meet any requirement from 2″ and larger diameters, in desired pitch and gauge, mounted on solid shafts, hollow shafts, or unmounted.



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A compact, highly efficient Link-Belt Helicoid screw conveyor is an important feature on the new Algoma Foundry & Machine Co's. O-K forage blower, (Algoma, Wis.), which blows hay into the mow, ensilage into the silo or grain into the granary.

Simple in design—only one part moves—the screw conveyor is unaffected by moisture or weather, needs no replacing, rarely requires maintenance, and is always ready for action. Positive and uniform movement of forage is assured by the screw conveyor and by Link-Belt roller chain, which also is an integral part of the blower.

Space-saving, trouble-free, easily adaptable Link-Belt screw conveyors are uniquely suited to agricultural implement purposes. Designers and manufacturers are invited to investigate the numerous advantages offered by Link-Belt's wide experience and facilities. Write the Link-Belt office nearest you.

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NEWS SECTION *(Continued from page 390)*

On the program of the conference are three papers by agricultural engineers, all members of the American Society of Agricultural Engineers. W. V. Hukill, principal agricultural engineer, U. S. Department of Agriculture, will present a paper on storage and preservation of agricultural products; Rene Guillou, head, agricultural engineering department, University of Hawaii, will present the subject of mechanization of tropical farming in Hawaii, and Mason Vaugh, agricultural engineer, Allahabad Agricultural Institute (India), will present a paper on simple tools and equipment for small-scale farming.

Canadian Ag Engineers Hold Meeting

THE agricultural engineers constituted the second largest group of subject-matter specialists in attendance at the 29th annual meeting and convention of the Agricultural Institute of Canada, held at the University of British Columbia, Vancouver, June 20 to 24. The program of this meeting included four sessions devoted to agricultural engineering subjects, two of which were joint with the soils section of AIC.

The agricultural engineers of Canada are organized in the Agricultural Engineering Section of the AIC, and at the Vancouver meeting of the Institute elected the following officers for the ensuing year: Chairman, J. Arnold Roberts, agricultural engineer, New Brunswick Department of Agriculture; secretary, S. L. Tallmann, engineering research department, Massey-Harris Co., and the following four directors: J. R. W. Young, head, agricultural engineering department, University of British Columbia; R. A. Schmidt, farm service engineer, Imperial Oil Limited, Regina, Sask.; W. J. Lavigne, supervisor, Rural Service Bureau, Shawinigan Water & Power Co., Montreal; and Angus Banting, director, Agricultural Engineering Services, Nova Scotia Department of Agriculture.

Personals of A.S.A.E. Members

Rajendra N. Pahalwan, employed as lecturer in the agricultural engineering department of the Allahabad Agricultural Institute, has joined the agricultural engineering department of the United Provinces Government and is at present working as assistant to the agricultural engineer (research), United Provinces Bareilly.

Dr. Herman Schildknecht, chief state engineer and professor of irrigation, Eidg Technische, Hochschule, Zurich, Switzerland, has resigned his position to accept appointment as senior construction engineer, irrigation department, for the Government of Ceylon and will be located at Colombo, Ceylon.

German Farm Machinery Show

TO THE EDITOR:

THE annual show sponsored by the German Agricultural Society at Hannover in June was devoted entirely to machinery, the first of its kind in the history of more than fifty of these events. At all other shows farm animals, products, and machines were displayed. At the recent show, however, there were only machines, and the project was undertaken at quite a risk for the Society as well as for the City of Hannover, because it was not certain that the machines only would be sufficiently attractive to visitors. The result showed that German farmers are aware of the necessity for increased mechanization, because they came from all parts of Germany to see what is new in agricultural engineering.

The horse or tractor-drawn, all-purpose machines for potatoes and beets — for planting, hoeing, weed killing and harvesting — have been improved. The small farmer cannot afford to buy a special machine for each of the numerous operations to be perforued in potato and beet growing. One machine with changeable attachments has to do the job.

The tractors shown, of which there were 50 different types, were all of the universal-purpose type. The "Alldos" are to be found from the 1½-hp garden tractor up to the large track layers. The designers experienced in the construction of machine tools, automobiles, and airplanes are now engaged in designing farm machinery and employing modern production methods.

Tractor-driving contests for young farmers are now as popular as horse riding and wagon driving used to be . Special equipment showed that even war invalids can handle horses and tractors, implements and machines.

The interest of farmers was great but the sales were not large. Farmers expect prices to drop further, yet manufacturers claim they have to cut their daily output and that therefore prices will rise instead of drop. We are waiting for the re-establishment of the old Figelag (agricultural machines investment bank) to improve the situation.

OTTO SCHNELLBACH

17a Eubigheim, Baden

Necrology

George Mills Foulkrod, head of the agricultural engineering department, University of New Hampshire, passed away June 23, at the Exeter Hospital, Exeter, N.H.

Mr. Foulkrod was a native of Pennsylvania. He graduated from the Pennsylvania State College and served on the faculty of its agricultural engineering department for a number of years before going to the University of New Hampshire in 1933. He became a member of the American Society of Agricultural Engineers in 1921, and worked consistently and effectively for the development, application, and recognition of agricultural engineering in the Northeast. He was a registered professional engineer in New Hampshire, a member of the farm electrification committee of the New England Council, chairman of the New Hampshire Electric Utilization Council, member of Tri-County Electrical Associates, and chairman of the New Hampshire Farm Safety Committee. He was also a member of the American Legion and a member and for many years secretary of Rising Star Lodge No. 47, F. and A. M.

Mr. Foulkrod is survived by his widow, Blanche; a daughter, Jean, on the faculty at Pennsylvania State College; a son, Robert, senior at the University of New Hampshire, and a sister, Dr. Emily Foulkrod, of Philadelphia.

New Literature

FARM BUILDING CONSTRUCTION BOOK No. 116. 68 pages, 11x16 inches. Starline, Inc., (Harvard, Ill., and Albany, N. Y.). Copies available to agricultural engineers on request to the company.

This book shows in drawings large enough to be a practical guide in design and construction, a wide range of recommended features, including sidewall sections for frame, block, and tile walls; heat transmission values for various types of wall and ceiling construction; typical ceilings for warm-air ventilation systems; cow stall floor details; pen floor details; hardware for outside and inside insulated sliding doors; details of insulated ceiling hay chute door; typical details of bull pen, paddock, door, and breeding stall; hay doors for gable end of barn; hardware for inside uninsulated sliding doors; sliding hay drive door; window details for various types of walls; glass block windows; steel window frame for wood sash; one-story barn details; framing details and elevations for braced rafter barns; arch-rib construction for standard light steel buildings; cross sections and construction details of laminated arch rafter barns; framing details and elevations for truss roof barns; typical plumbing details; standard milk house details; typical barn floor plans and general design data; typical plans of milking parlors; and milking stall installation details.

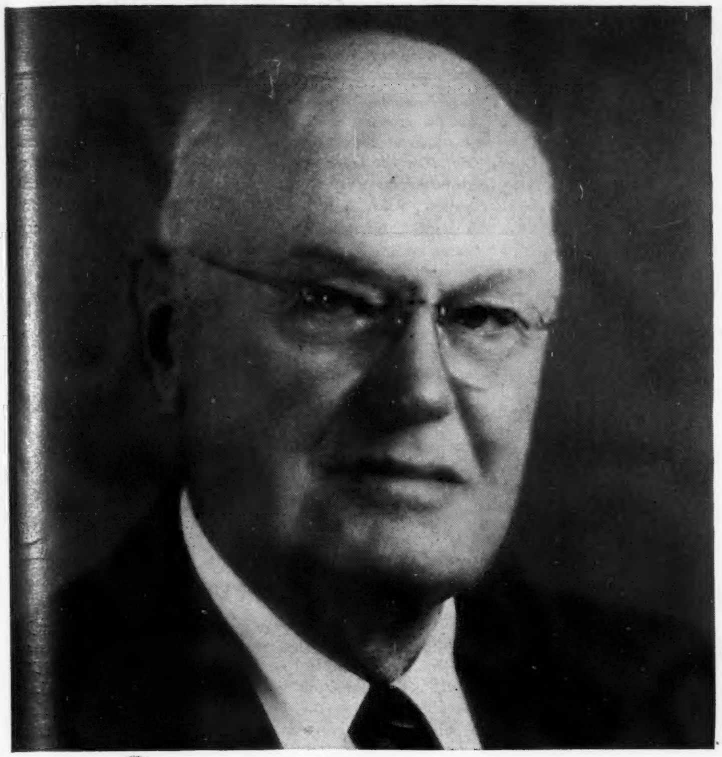
THE FARM BOOK, A GUIDE TO BETTER FARMING WITH BETTER BUILDINGS. Paper, 94 pages, 9 x 12 inches. Illustrated and indexed. West Coast Woods (1410 S.W. Morrison, Portland 5, Ore.) and Doane Agricultural Digest (5144 Delmar Blvd., St. Louis 8, Mo.) $1.00.

This is a practical handbook emphasizing use requirements, labor saving, and convenience, attained at low cost by design, selection of materials, and effective maintenance, based on the wide experience of the Doane Agricultural Service. It deals particularly with wood construction, but includes a wealth of information applicable to farm building irrespective of materials to be used. Much of the information on size requirements and justifiable costs is condensed into easily read tables. Layouts, floor plans, and material-saving structural details are illustrated. Chapter titles are: Farm buildings make money, Determining type and size of buildings, Can livestock pay rent?, New ideas in farm buildings, Proper building improvements reduce farmstead work, Construction features that save money, Efficient layout of farm buildings conserves space and time, Farm homes for a "Heap of Living;" Livestock, crop, and machinery storage requirements; Lumber use guides, Planning your building program, and Who should build your improvements.

FAMILY HOUSING, by Deane G. Carter and Keith H. Hinchcliff. Cloth, viii + 265 pages, 5½x8½ inches. John Wiley and Sons (New York), $4.00.

This is a college text and a reference for others with a personal or professional interest in housing the family. Chapters cover the introduction, public problems of housing, resources for planning, approach to house planning, kitchen and workroom, living and sleeping quarters, general planning problems, planning for remodeling, farmhouses, planning home equipment, protective qualities, basic measurements, house structure, choosing materials, costs and material quantities, economic and financing problems, and acquiring home ownership. Appendixes cover housing problem study and references for housing study.

Published by the **Ethyl Corporation** to help promote the most efficient type of farm power.



Who's who in tractor sales. In 1948 the Holman brothers, famous in Georgia as mule dealers since 1906, acquired the Ferguson Tractor and Implement dealership at Albany, Georgia. Although Mr. W. C. Holman, head of the organization, used to have an average sale of 2000 mules a year, he realized that the future in farm power was with modern and efficient farm equipment. Besides their dealership, the Holmans own and operate an 1100-acre farm on which they average annually 125 acres of corn, 200 acres of oats, 60 acres of peanuts and 200 acres of pasture and hay land. In addition, they have a 100-acre pecan grove and 150 head of white-face cattle utilize the forage and grain produced on their farm. The Holmans know farm power both as dealers and users.

"High compression helps my business... helps my customers,"

says ***W. C. Holman,***
Harry Ferguson dealer of Albany, Georgia

"When customer after customer asks for high compression tractors, you can be sure there's a mighty good reason for it. Modern gasoline-operated engines give the farmer what he wants most in a new tractor—more power!

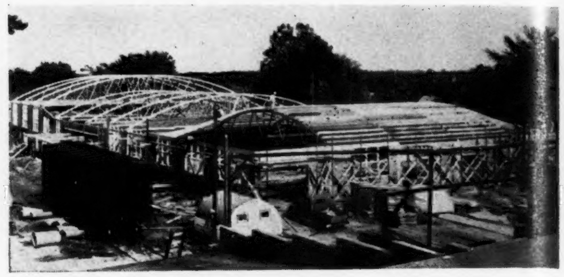
"With one of our new Ferguson high compression models, farmers not only get more power, but quicker starting, faster warm-up, smoother idling and cleaner burning of fuel. By giving farmers everything they want, high compression keeps my customers satisfied . . . helps my business."

Mr. Holman knows what he's talking about. Farmers in all forty-eight states want the better performance and extra power that high compression tractors deliver. That's why eighty per cent of the tractors being manufactured today have high compression engines.

NEWS FROM ADVERTISERS

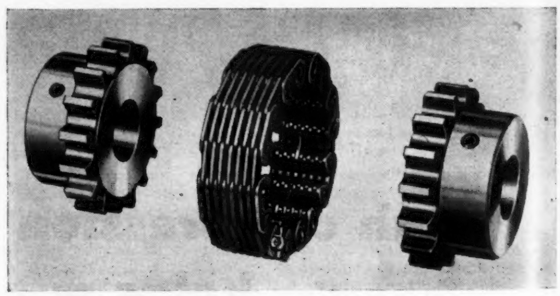
New Products and Literature Announced by AGRICULTURAL ENGINEERING Advertisers

Rilco Glued-Laminated Framing Members. A new building, designed to meet the growing demand for glued-laminated framing members, is being added to the products of Rilco Laminated Products, Inc., St. Paul, Minn. The accompanying photograph shows various spans of standard Rilco bowstring trusses used in the roof framing of a modern, U-shaped addition. Rilco designs and produces glued-laminated wood products and framing members for a wide variety of commercial and farm uses. Farm rafters, trusses, arches, wagon boxes, and wood parts for industry are some of the products built by Rilco.



A new building of Rilco glued-laminated framing members

Morse Series DSC Flexible Couplings. Morse Chain Co., Division of Borg-Warner Corp., Detroit, Mich., has developed a completely new line of stock silent chain flexible couplings designated as Series DSC. The rugged, all-steel construction of these new couplings combines maximum power transmission capacity with minimum space requirement. The simplicity of design — two sprockets wrapped with a center guide Morse Silent Chain — assures easy installation. Disconnection is accomplished quickly and easily by either of two methods: by unwrapping of the chain after removing the single connecting pin, or by moving either sprocket endwise out of mesh with the chain. Stock bores range from ½ to 2⅞ in, with capacities up to 119 hp at 2000 rpm. Two covers are available — stamped steel for economy and plastic for maximum protection.



Morse Series DSC flexible couplings

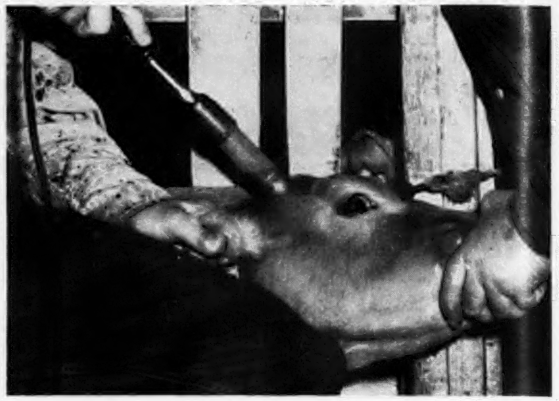
The History of Modern Forage Harvesting, by R. C. Krueger, has been published by the Fox River Tractor Co., Appleton, Wis., in the form of a 6x9-inch booklet of 28 pages, in two colors. It briefly reviews contributions of the Company and of users of its products, from the beginning of hay chopping with silo fillers in the 1920's, through the development of hay-feeding attachments, windrow pickup, field hay chopper, corn ensilage harvester, pickup hay cutters with side and rear-delivery carriers, grass silage harvesters, and row-crop attachments, to the present line of equipment, its performance, and recommended use methods.

General Electric — In the Home — On the Farm is a new 87-page, 8½ x 11-inch catalog of the General Electric Company's home and farm equipment line, with general information, construction and operating features, and specifications where appropriate, on refrigerators, home freezers, walk-in refrigerator equipment, ranges, water heaters, electric sinks, dishwashers, storage cabinets, automatic washers, clothes driers, ironers, fans, radio, television, lamps, motors, stock tank water heaters, time switches, welders, wiring materials, oil-burning heaters and numerous other items. *(Continued on page 396)*

News from Advertisers

(Continued from page 394)

The new "General Electric" electric de-horner removes calves' horns quickly, less painfully, and in an entirely bloodless operation, according to the Farm Industry Division, General Electric Co., Schenectady, N. Y. Besides reducing the danger of infection due to open sores on the animal's head, the new electric device is considerably faster than conventional de-horning methods, requiring only 2 minutes for the entire operation after the tip has been allowed to heat. The equipment consists of a 300-watt soldering iron with two interchangeable tips — a soldering tip and the special de-horning tip. The de-horning tip applied over the budding horn button sears and cauterizes the tissues, killing the growth cells at the base of the horn. Within a few weeks both scab and horn fall off, leaving a smooth, clean-looking head. The electric dehoner operates on a 115-volt a-c circuit.



The new GE de-horner in use

The Delavan "Select-A-Spray", a master control for farm sprayers, has been announced by Delavan Mfg. Co., Des Moines, Iowa. The new 8-way valve is designed for mounting on tractors within easy reach of the operator. It controls the spray in the left, right, and center boom sections or any combination of the three, to provide 8 different spraying combinations from "off" to completely "on". It costs no more than the individual hand valves and fittings it replaces, according to the manufacturer. It can be very easily mounted on any tractor and is said to work perfectly with any sprayer. The valve is made of bronze to resist corrosion and is built to withstand 200 lb pressure. Quarter-inch outlets to boom sections assure adequate flow for 30 nozzles.

The Delevan "Select-A-Spray"

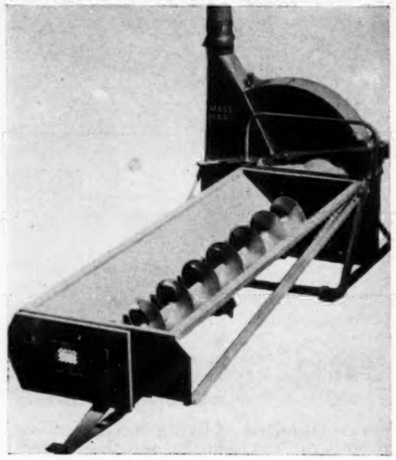
"Johns-Manville Decorative Insulating Board" is the title of a new J-M publication describing ceiling panels, wall plank, and building board, three of the most popular forms in which J-M insulating board is made. Full color illustration suggest the many types of rooms which can be built with these versatile products either in new construction or remodeling. The text provides information on sizes, application, and special features such as the ready-to-use glazecoat finish and the lightning joint that conceals nailing. Ideas for commercial and institutional as well as residential interiors are included.

(Continued on page 398)

News from Advertisers

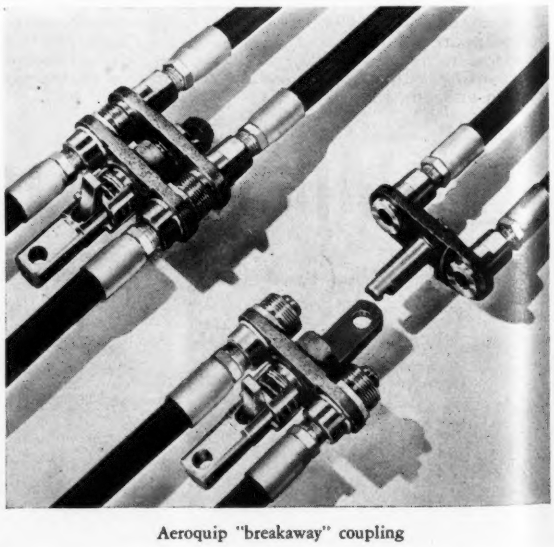
(Continued from page 396)

Massey-Harris Forage Blower. Among the special features of the new Massey-Harris forage blower are the large table and 12-in diameter auger, with patented off-center feed to the blower which avoids any chance of center chunks forming which can break loose and jam or plug the pipe. A large six-bladed fan with low-speed sweeping action picks up the forage at the bottom of the fan housing and in about 90 deg of rotation sends it up the pipe, gentle on the crops with no milling or grinding. The variable-speed auger drive may be adjusted to fit the crop conditions and the power source. A spring-balanced feed table is easily raised for wagons to be driven straight through, thus avoiding any tricky maneuvering or backing. Semipneumatic rubber-tire wheels are used for transport. The machine is capable of putting up 35 tons of green corn silage an hour.

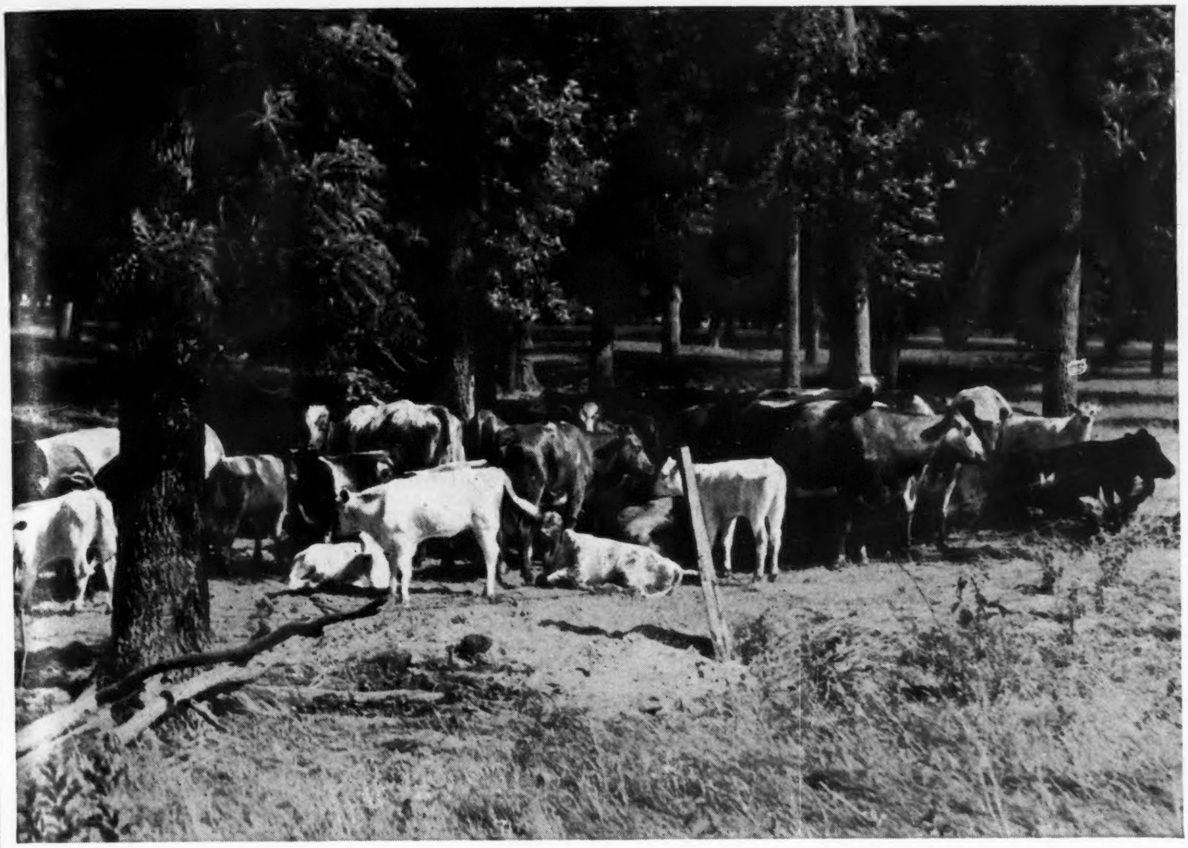


Massey-Harris forage blower

The Aeroquip "Breakaway" Coupling specially designed for users of modern, hydraulically controlled farm equipment, is now in production by the Aeroquip Corp., Jackson, Mich. The coupling is a twin unit connecting both hydraulic pressure and return lines between tractor and implement. Using two self-sealing couplings mounted in a frame and held in a coupled position by a mechanical latch, the "Breakaway" coupling disconnects automatically when an external pull is applied to the connecting hydraulic lines. The coupling may also be disconnected manually by tripping the latch, and connected with ease even when the lines are under pressure. Thus the tractor is always available for use with other hydraulically operated implements or for other purposes since connecting and disconnecting tractor and implement is a simple operation completed in a few seconds.



Aeroquip "breakaway" coupling



A romantic scene of ruinous farming

There are few sights more beautiful than a herd or flock patiently munching grass in a grove of trees or in the woodlot.

But there are few farm practices more damaging.

The constant stomping of animals, pounds down and compresses the natural mulch of decaying vegetation. Instead of acting as a sponge to hold moisture and raise the water table of the surrounding land, it permits rainfall to run off.

Moreover, in the eating of the grass, livestock also eat the sprouting young trees that Nature plants to replace the mature timber that can be harvested each year as a cash crop.

Conservation is a lot of things. It is putting land to best usage . . . marginal land in timber . . . other land in grass and pasture . . . the best land in field crops. It is contouring and strip cropping the slopes . . . slowing down fast moving streams . . . building ponds for holding water for irrigation, livestock, and recreation.

In short, conservation is taking the long view instead of the short one . . . putting agriculture on a permanently profitable basis for our sons and their sons as well as for ourselves.

Too much good land has already been plundered. Conserving what is left is a needed job for all . . . for us who build farm machinery, for the farmer who uses it, for you who are guide and confidant to America's 6,000,000 farmers.

The Massey-Harris Company
Quality Avenue • Racine, Wisconsin

Manufacturers of tractors, combines, corn pickers, forage harvesters, and a full line of other farm machinery for more than a hundred years.

Make it a Massey-Harris

MASSEY M·H HARRIS

TRACTORS
COMBINES
IMPLEMENTS

Applicants for Membership

The following is a list of recent applicants for membership in the American Society of Agricultural Engineers. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Artus, Charles H.—Junior engineer, John Deere Waterloo Tractor Wks., Waterloo, Iowa (Mail) 921 Adrian St.

Berryhill, Gerald W.—Junior engineer, J. I. Case Co. (Mail) 1131 Tremont Ave., Davenport, Iowa.

Bittinger, Morton W.—Instructor in agricultural engineering, Iowa State College, Ames, Iowa (Mail) 2308 Donald.

Black, Donald T.—Twin Valley Farm, E. Pepperell, Mass.

Bruce, W. M.—Associate agricultural engineer, Bureau of Plant Industy, Soils, and Agricultural Engineering, USDA (Mail) Athens, Ga.

Dalrymple, Malcolm P.—Farm service representative, New Jersey Power & Light Co., 57 Trinity St., Newton, N. J.

Dorothy, Robert E.—Land appraisal engineer, U. S. Bureau of Reclamation (Mail) 502 Yellowstone Ave., Billings, Mont.

Finden, Kenneth A.—Engineer, Smalley Mfg. Co., Manitowoc, Wis. (Mail) Apt. 920 A, South 32nd St.

Godwin, Winston Y.—Manager, Godwin Livestock Co., Summerton, S. C.

Griffith, Walter R.—Agricultural engineer (irrigation), Soil Conservation Service, USDA (Mail) Dimmitt, Tex.

Harris, William S.—Engineer trainee, Soil Conservation Service, USDA (Mail) 213 North 2nd St., Monmouth, Ill.

Herbig, Lawrence R.—Agricultural sales engineer, Illinois Northern Utilities Co. (Mail) 213-215 W. Stephenson St., Freeport, Ill.

Hill, Charles L., Jr.—Trainee, Massey-Harris Co., Racine, Wis. (Mail) R. R. 3, Box 86.

Jochens, Leslie W.—Assistant engineer, Farm Improvement Co., 3523 Blake St., Denver 5, Colo.

Keller, Frank J.—Hydraulic design work, Soil Conservation Service, USDA (Mail) 2519 South Coral St., Sioux City, Iowa.

Keppel, Robert V.—Agricultural engineer, Soil Conservation Service, USDA (Mail) 215 Lincoln Ave., Crookston, Minn.

Miller, Loren W.—Field testing and designing implement div., Detroit Harvester Co. (Mail) R. R. 4, Muncie, Ind.

Mills, William T.—Irrigation sales engineer, Schroer Implement Co., Valdosta, Ga. (Mail) 314 North Ashley St.

Oyler, Ralph L.—Trainee, Allis-Chalmers Mfg. Co., Milwaukee, Wis. (Mail) 8915 W. Greenfield Ave.

Peart, Robert M.—Power use engineer, Eastern Iowa Light & Power Cooperative, Wilton Junction, Iowa.

Pederson, Donald L.—Engineering specialist, Soil Conservation Service, USDA (Mail) Greenfield, Iowa.

Pillsbury, Arthur T.—Associate professor of irrigation, University of California, Los Angeles 24, Calif.

Raney, Russell R.—Assistant chief engineer, McCormick Works, International Harvester Co., 26th & Western Ave., Chicago 8, Ill.

Ritchie, James, Jr.—Student, North Carolina State College, Raleigh, N. C. (Mail) Apt. 33-F, Vetville, State College Sta.

Scott, William P.—Farm service engineer, The Detroit Edison Co., 20000 Second Ave., Detroit 26, Mich.

Seidel, Fred W.—Civil engineer, Soil Conservation Service, USDA, 3600 McCart, Fort Worth, Tex.

Sprawls, Aubrey D.—Farm service representative, Gulf States Utilities Co., Beaumont, Tex. (Mail) Box 3381.

Thompson, Lawrence, J.—Soil conservation engineer, Carson Indian Agency, Stewart, Nevada.

Zeltwanger, Earl D.—Design engineer, The Oliver Corp. (Mail) Bremen, Ind.

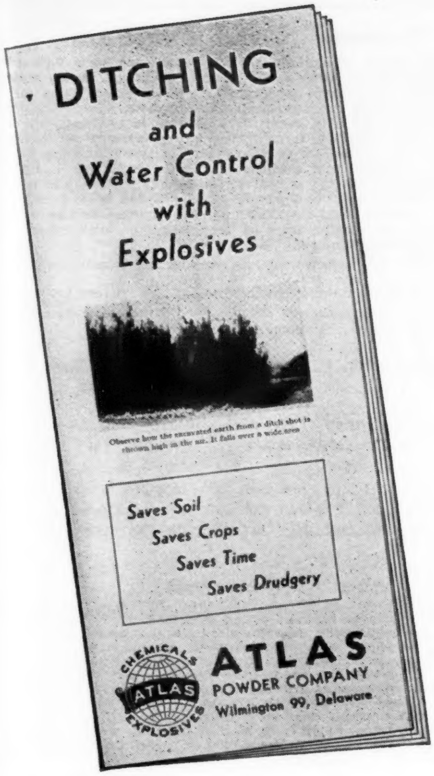
TRANSFER OF GRADE

Morrison, Charles S.—Research engineer, Deere & Co., Moline, Ill. (Junior Member to Member)

E. J. Matthews—Instructor in agricultural engineering, University of Tennessee, Knoxville, Tenn. (Junior Member to Member)

New Federal and State Bulletins

The Nebraska Tractor Tests — 1920 - 1948. Bulletin 392 (January 1949) Nebraska Agricultural Experiment Station (Lincoln). Presents information on the general procedure and rules, belt tests, drawbar tests, end of tests, interpretation of summary sheet, horsepower, drawbar testing equipment, tractors using rubber tires, the law, and tractor specifications. The latter are given only for tractors which have passed the tests and which were reported by their manufacturers as being on the market January 1, 1949. An accompanying summary chart gives the results of the tests on these same tractors.



Get This Free Booklet—

Tells How To Get Best Results From Ditch Blasting For Water Control

Every Agricultural Engineer knows the importance of water control in soil conservation. More and more men in agriculture are discovering the benefits of ditching with explosives. This booklet puts you in the know on this speedy, easy, economical method of ditching without expensive equipment.

It's chock full of information and advice—tells how explosives work in ditching—describes propagated ditch blasting and electric ditch blasting—explains laying out the ditch, loading, right-of-way clearing—describes how large, wide and wide-shallow ditches are blasted.

There's a heap of further information in this booklet and—if you use explosives for ditching—it's yours for the asking. Write today for your copy.

ATLAS EXPLOSIVES

"Everything for Blasting"

CHEMICALS ATLAS EXPLOSIVES

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Personnel Service Bulletin

The American Society of Agricultural Engineers conducts a Personnel Service at its headquarters office in St. Joseph, Michigan, as a clearing house (not a placement bureau) for putting agricultural engineers seeking employment or change of employment in touch with possible employers of their services, and vice versa. The service is rendered without charge, and information on how to use it will be furnished by the Society. The Society does not investigate or guarantee the representations made by parties listed. This bulletin contains the active listing of "Positions Open" and "Positions Wanted" on file at the Society's office, and information on each in the form of separate mimeographed sheets, may be had on request. "Agricultural Engineer" as used in these listings, is not intended to imply any specific level of proficiency, or registration, or license as a professional engineer.

NOTE: In this Bulletin the following listings still current and previously reported are not repeated in detail. For further information see the issue of AGRICULTURAL ENGINEERING indicated.

POSITIONS OPEN: 1948. JULY—O-627, 630. 1949. MARCH—O-662, 663. MAY—O-667, 668, 669. JUNE—O-671. JULY—O-672, 673, 674.

POSITIONS WANTED: 1949. JANUARY—W-212, 215, 216. FEBRUARY—W-219, 220, 222. MARCH—W-227, 232, 233, 236. APRIL—W-237, 238, 239, 240, 243, 245, 247, 248. MAY—W-250, 253, 254, 258, 259, 260, 261, 262, 263, 264, 265, 266, 268, 269, 271, 272, 273. JUNE—W-275, 277, 278, 279, 280, 281, 282, 283. JULY—W-285, 286, 287, 288, 289, 290, 291, 292, 293, 294, 295, 296, 297, 298, 299, 300, 301, 302.

NEW POSITIONS OPEN

DRAFTSMAN, in farm machinery and structures field, for work in college agricultural engineering department in the Southeast. Work will include drafting incidental to research projects, service work for teaching and other departments, and supervision of student and other draftsmen. BS deg in agricultural engineering desirable but not essential. Farm background, mechanical drafting experience, and knowledge of shading desired. Some free hand artistic ability would also be useful. Usual personal qualifications for work in a college. Opportunity for study toward advancement in other lines of engineering work. Excellent retirement system. Age 24-30. Salary $3000 or higher to start, depending on qualifications. O-34-675

RESEARCH INSTRUCTOR in agricultural engineering for work on the mechanization of peanut production, in a college agricultural engineering department in the Southeast. Will be assistant to project leader, in work on methods, equipment, and efficiency experiments. BS deg in agricultural engineering or equivalent. Farm background, with fair drafting ability, and capacity for some design and development work with minimum supervision desired. Should be good observer, machinery minded, with initiative and imagination. If work is satisfactory advancement will be as rapid as usual in college work. Excellent research shop. Transportation in connection with work furnished. Excellent retirement system. Age 24-30. Salary $3240, one month vacation. O-34-676

RESEARCH INSTRUCTOR in agricultural engineering for work on mechanization of cotton production, in a college agricultural engineering department in the Southeast. Will be assistant to project leader, developing methods and equipment, and conducting efficiency experiments in planting, fertilization, weed control, and cultivation. BS deg in agricultural engineering, or equivalent. Desire man with farm background, fair ability as draftsman, and capacity for some design and development work with supervision. Usual personal qualifications for college work. Good opportunity for advancement. Excellent retirement system. Age 24-30. Salary $3240, one month vacation. O-34-677

RESEARCH ASSISTANT PROFESSOR of agricultural engineering for work in developing techniques and equipment for more efficient handling of tobacco in sorting, grading, and marketing, in a college agricultural engineering department in the Southeast. MS deg in agricultural or electrical engineering preferred. BS deg may be considered where agricultural engineering and substantial training in electronics are combined. Basic training in electronics essential. Farm background highly desirable. Knowledge of tobacco growing helpful but not essential. Usual personal qualifications for college work. Excellent opportunity in field of tobacco harvesting and handling. Excellent retirement system. Age 24-35. Salary $4000 or higher to start, one month vacation. O-34-678

IRRIGATION ENGINEER for irrigation, flood control, drainage, and navigation works in India. Engineering training, experience, and administrative ability in these fields adequate to furnish competent guidance on preparation of plans. Free medical service, first class passage for family both ways, 5-yr contract. Age — under 50. Salary $9000-11000. Applications desired immediately. O-58-679

AGRICULTURAL ENGINEER for field work in connection with use of ground water for irrigation and sales of water well equipment. Engineering training and experience adequate for effective study of potentialities of pump irrigation in any given territory; interpreting hydrological data, particularly in ground water studies; and making field surveys concerning pump irrigation. Work also requires man with good appearance and ability to meet people easily. Must be willing to travel extensively in Midwest and West. Traveling expenses furnished. Age 28-40. Salary open. O-59-680

NEW POSITIONS WANTED

SALES OR SERVICE work in power and machinery field wanted by recent graduate in agricultural engineering, Michigan State College. Farm background, plus one summer in small grain harvest on combine and tractor operation, maintenance, and repair; and part time work as student assistant in research, agricultural engineering department, Michigan State College. Single, 22. No disability. Available Aug. 15. Salary open. W-16-303

(Continued on page 404)